# AERIAL PHOTOGRAPH ASSESSMENT AND REACH STRATIFICATION
# UPPER GALLATIN WATERSHED

*Quality Assurance Project Plan (QAPP)*

**Prepared for:**

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# 1.0 PROJECT MANAGEMENT

## 1.1 Project Background

The Montana Department of Environmental Quality is required to develop a TMDL water quality restoration plan by 2007 for the Upper Gallatin River TMDL Planning Area (TPA) in order to satisfy state law as well as federal court requirements. The Upper Gallatin River TPA includes the mainstem of the Gallatin River from the headwaters to Spanish Creek, Cache Creek, Middle Fork West Fork Gallatin River, South Fork West Fork Gallatin River, Squaw Creek, Taylor Fork, and West Fork Gallatin River.

The purpose of this document is to present a quality assurance project plan (QAPP) to direct aerial assessments in the Upper Gallatin River watershed. This QAPP describes the quality assurance program that will accompany the assessment activities, and presents details regarding the project organization, measurement quality objectives, data documentation and collection, data management, response actions, and data validation. This QAPP is intended to outline a consistent and acceptable approach to data collection and management that will facilitate achievement of program objectives. Implementation of this QAPP will help ensure that all data collected, compiled, and/or generated for this monitoring project are complete, accurate, and of the type, quantity, and quality required for their intended use.

Under U.S. Environmental Protection Agency Order 5360.1 A2, all organizations conducting environmental programs funded by EPA are required to establish and implement a quality system. Additionally, EPA requires that all data used for purposes of environmental decision-making must be supported by an approved Quality Assurance Project Plan. This QAPP intends to satisfy these requirements, and has been prepared according to guidance provided in *EPA Requirements for Quality Assurance Project Plans*, and *Guidance for Quality Assurance Project Plans* (EPA 2001, 2002). Additional EPA quality system references that were consulted in the preparation of this document include *Guidance for the Data Quality Objectives Process* and *Guidance for Data Quality Assessment: Practical Methods for Data Analysis* (EPA 2000, EPA 2002).

This QAPP addresses the aerial photograph assessment and reach inventory activities scheduled for 2005. It is important to note here that the scope of the proposed assessment described in this document may change somewhat due to project developments. However, the quality assurance elements described in this QAPP will still apply regardless of any final adjustments to the assessment plans.

## 1.2 Project/Task Organization

This section outlines the project personnel and organizations associated with the various elements of the monitoring programs. Project participant roles are defined in **Table 1-1**.

**Table 1-1.** ***Project Personnel Roles***

| Name | Organization | Project Responsibilities |
|---|---|---|
| Pete Schade | MT Dept. of Environmental Quality | 319 Grant Administrator |
| Taylor Greenup | PBS&J | Project Manager |
| Mark Bostrom | MT Dept. of Environmental Quality | DEQ QA Officer |
| Robin Rung | MT Dept. of Environmental Quality | DEQ Contract Officer |

The 319 grant administrator at the Montana Department of Environmental Quality is Pete Schade. Pete is responsible for contract oversight and review of all project deliverables.

The Upper Gallatin Watershed aerial photograph assessment project manager is Taylor Greenup, watershed specialist and GIS analyst with PBS&J. The project manager will provide general oversight and coordination to the project and assessment activities. She will also be responsible for reviewing the assessment procedures and results to ensure that measurement quality objectives and quality control requirements are met. In addition, Gary Ingman, Senior Biologist with PBS&J, will be providing technical guidance for this project.

Mark Bostrom of the Montana Department of Environmental Quality Water Quality Planning Bureau is the state water quality monitoring quality assurance officer.

Robin Rung of the Montana Department of Environmental Quality Water Quality Planning Bureau is the DEQ contract officer.

### 1.3 Problem Definition/Background

In the State of Montana, growth and propagation of fish and associated aquatic life, drinking water, agriculture, industrial supply, recreation, and wildlife are considered beneficial uses of water bodies. Water bodies failing to support one or more beneficial uses are described as impaired on the 303(d) List and the development of a water quality restoration plan is required. The State of Montana considers the Gallatin River within Yellowstone National Park an A-1 waterbody, while the Gallatin River between the Yellowstone National Park boundary and Spanish Creek is classified as B-1. Tributaries of the Gallatin River outside of Yellowstone National Park are also classified B-1. Waters classified as A-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities, while waters classified B-1 are to be maintained suitable for drinking, culinary and food processing purposes, after conventional treatment. Both A-1 and B-1 waterbodies must be maintained suitable for bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply (MCA 17.30.622(1)(2) and 17.30.623(1)).

In 2004, the *303(d) List of Impaired and Threatened Waterbodies in Need of Water Quality Restoration* was combined with the 305(b) Report into the *2004 Montana Water Quality Integrated Report*. The 2004 Integrated Report incorporates new guidance from the EPA which requires total maximum daily loads (TMDLs) be developed for waters impaired by "pollutants," such as nutrients, sediment, or metals. TMDLs are not required for waters impaired solely by

"pollution," such as flow alterations or habitat degradation (MDEQ 2004a). On the 2004 Integrated Report, Cache Creek, Middle Fork West Fork Gallatin River, South Fork West Fork Gallatin River, Squaw Creek, Taylor Fork, and West Fork Gallatin River are considered Category 5 waterbodies with one or more impaired uses that require the development of a TMDL. The mainstem of the Gallatin River between the Yellowstone National Park boundary and Spanish Creek is described as a Category 3 water body on the 2004 Integrated Report, indicating that those uses assessed are fully supported, though some uses (aquatic life, coldwater fishery, drinking water, recreation) are not assessed. The Gallatin River within Yellowstone National Park lacked sufficient credible data to assess any use.

Streams listed as Category 5 waterbodies in the Upper Gallatin River TPA on the 2004 Integrated Report are all listed as partially supporting aquatic life and coldwater fishery beneficial uses. In addition, the Middle Fork West Fork Gallatin River and South Fork West Fork Gallatin River are listed as partially supporting recreation uses. The Taylor Fork is listed as partially supporting industrial uses, while the West Fork Gallatin River is described as not supporting recreation beneficial uses. All other assessed uses are fully supported. Fisheries, recreation and resort community development are the dominant water uses in the Upper Gallatin Watershed. The most frequently cited causes of impairment in the Upper Gallatin River TPA are siltation, nutrients and other habitat alterations. The most frequently cited sources of impairment in the Upper Gallatin River TPA are construction (land development), land disposal and silviculture (logging road construction /maintenance).

The aerial photograph assessment and reach inventory will focus on identifying sources and the magnitude and locations of water quality impairments associated with sediment, nutrients, and riparian and aquatic habitat degradation. This investigation will consist of two phases: 1) an assessment of the Gallatin River mainstem (Specimen Creek to Spanish Creek), Cache Creek, Dudley Creek, Squaw Creek, and Taylor Fork using aerial photography from 1999 and 2) an assessment of the Middle Fork West Fork Gallatin River, South Fork West Fork Gallatin River and West Fork Gallatin River using up-to-date Ikonos satellite imagery. The mainstem of the Gallatin River within Yellowstone National Park will also be assessed from aerial photographs in the second phase. Project goals include: 1) assessing existing channel, riparian, and land-use conditions, 2) identifying major sources of pollution to the 303(d) listed streams, and 3) creation of a spatial database summarizing the results of the investigation.

## 1.4 Project/Task Description and Schedule

This phase of the project involves an aerial assessment of many of the 303(d) listed streams in the Upper Gallatin River TPA, as well as the mainstem of the Gallatin River and Dudley Creek. Streams to be assessed include:

- Gallatin River (Specimen Creek to Spanish Creek)
- Cache Creek
- Dudley Creek
- Squaw Creek
- Taylor Fork

The aerial assessment will involve segmenting the streams into reaches with similar Rosgen stream type, riparian vegetation, land-use, and land ownership. This aerial photograph assessment will provide a framework for future monitoring and modeling efforts and impairment status determinations within the Upper Gallatin River TPA. This assessment will provide information directly related to siltation impairments through the mapping of channel morphology and riparian conditions along the inventoried segments. Sources of siltation impairments such as eroding stream banks, the loss of riparian vegetation, and adjacent land use-practices will be identified. It is anticipated that this assessment will also provide information useful for assessing nutrient related impairments by identifying land-use practices that may be potential sources of nutrient loads. In addition, this assessment will provide information useful for determining beneficial use support for aquatic life, coldwater fishery, drinking water, and recreation along the mainstem of the Gallatin River upstream of Spanish Creek.

The products of this assessment will be a narrative interpretive report summarizing key findings for each water body on a reach-specific basis and a MS Access database containing information gathered during the aerial photograph assessment. All of the data collected during the aerial photograph assessment and reach inventory will be assembled into an ArcGIS geodatabase and ArcGIS map project. The tabular data will be exported upon completion to MS Access format to facilitate use and accessibility. The ArcGIS geodatabase will be linked to an edited version of the high resolution National Hydrography Dataset (a routed GIS layer). Each table will have fields that will link to a specific stream reach and will allow for map display of the inventoried channel, riparian and land-use features. Data tables and maps will accompany the report and electronic versions will be made available. Metadata for the spatial data will be provided in the FGDC format.

## 1.5 Measurement Quality Objectives

Measurement quality objectives (MQOs) are the quantitative and qualitative terms used to specify how good the data need to be to meet the project's specific monitoring objectives. MQOs for measurement data, also referred to as data quality indicators, include precision, accuracy, measurement range, representativeness, completeness, and comparability. Measurement quality objectives for the Upper Gallatin River TPA aerial photograph assessment are addressed below.

### 1.5.1 Precision

*Precision* refers to the degree of variability in replicate measurements. Precision for parameters measured on aerial photographs will depend on the visibility of terrain features and the measurement instrumentation used. Terrain visibility is controlled by many factors such as air photo scale, atmospheric interference, and canopy cover. Precision for the air photo survey will be evaluated by conducting repeat measurements. For this project an initial precision goal of 15 percent will be established for air photo analyses.

### 1.5.2 Accuracy

*Accuracy* is a measure of confidence that describes how close a measurement is to its "true" value, or the combination of high precision and low bias. The “true” value of assessment

measurements may not be attainable; however, potential bias in the program procedures will be minimized by strict adherence to the QAPP.

Measurements taken on aerial photographs and topographic maps are closely tied to scale. Accurate photo measurements can be particularly difficult on photos where the ground elevations are varied (i.e. mountains). Where possible, in mountainous areas photo measurements will be made using the average photo scale (if there are features present with known lengths). A GIS project with digital topographic maps, digital elevation grids, and other relevant layers will be used to aide the photo interpretation. For this project, an initial accuracy goal of 25 percent will be established for aerial measurements.

### 1.5.3 Measurement Range

*Measurement Range* is the range of reliable readings of an instrument or measuring device, as specified by the manufacturer. A Tamaya Super Planixβ™ planimeter will be used to measure line features on aerial photographs. The measurement ranges for assessment instrumentation are specified in the operation manual of the instrument. The factory-determined measurement ranges have been adopted for assessment measurements under this project. An operation manual will be kept with the instrument and will be read and understood before using.

### 1.5.4 Representativeness

Representativeness is the extent to which the measurements actually represent the true environmental conditions. Representativeness will be achieved through adherence to the assessment protocols and procedures outlined in this QAPP.

### 1.5.5 Completeness

Completeness is the comparison between the amounts of data that were planned to be collected versus how much usable data was actually collected, expressed as a percentage. Data may be determined to be unusable in the validation process. A project completeness of greater than 90 percent is expected under normal operating conditions; however, incomplete air photo coverage may preclude desired project completion.

### 1.5.6 Comparability

Comparability is the degree to which data can be compared directly to previously collected data. Data produced from this assessment project will be obtained by using standard procedures, and can be compared to past assessment data within the watershed, provided that data were collected using the same or similar procedures. Comparability will be achieved for this project through consistent procedures and analyses as outlined in this QAPP.

## 1.6 Training Needs and Certifications

No special training or certifications are required for analysts or data managers of this project. However, strict adherence to assessment methodology described in **Section 2.0** of the QAPP is

required to ensure compliance with measurement quality objectives (MQOs). Assessment oversight and training will be the responsibility of the project manager.

### 1.7 Records Management

The documents and records produced from this project will consist of spatial data (maps, shapefiles, geodatabase, and metadata), aerial photographs, and a narrative summary report. The narrative interpretive report of the 2005 Upper Gallatin Watershed Aerial Photography Assessment and Reach Inventory prepared by PBS&J personnel will serve as the summary product for all assessment aspects of the Upper Gallatin Watershed described in this QAPP.

Additional project documents will be generated during the course of the assessment program, and will be maintained by the project manager. These documents may include the following:

1. *Project Updates*. These include the completed project activities and more detailed evaluations of the assessment program.
2. Data and Methodology QA/QC Evaluations. These include documentation of QA/QC reviews that include data validation, assessment, and response actions, and other issues that may arise during the course of the assessment program.
3. Communication Records. These include records of relevant communication between project team members and agencies, and program sponsors.

In addition to hardcopy or paper documents, computer files will be generated during the course of the assessment project. The project manager will maintain these files during the course of the program. The project manager will also maintain copies of all program documents on a regular basis for incorporation into a central project file.

## 2.0 DATA GENERATION AND ACQUISITION

This section presents additional details pertaining to data generation and acquisition for the 2004 Upper Gallatin Watershed aerial photograph assessment and reach inventory. Components of this section include the following:

2.1 Assessment Design and Schedule
2.2 Assessment Methods Requirements
2.3 Instrument Calibration, Testing, Inspection, and Maintenance
2.4 Non-Direct Measurements
2.5 Data Management

### 2.1 Assessment Design and Schedule

The aerial photograph assessment and reach inventory project described in this quality assurance project plan reflects an assessment strategy designed to document existing stream channel and riparian conditions, along with current land-use practices and potential sources of pollution, for the 303(d) listed streams of the Upper Gallatin TPA. The projected timeframe for completion is approximately four months.

The first phase of the effort will be the collection and analysis of aerial photographs from 1999 along several of the 303(d)-listed streams in the Upper Gallatin TPA. The second phase will consist of collection and analysis of up-to-data Ikonos satellite imagery of 303(d)-listed streams located in the West Fork Gallatin River watershed. The main product of the aerial photograph assessment will be a geodatabase linked to a modified version of the high resolution National Hydrography Dataset (routed GIS layer, 1:24,000). Tables 2-1 to 2-4 outline the data template for the aerial photograph assessment geodatabase.

***Table 2-1. Reach Parameters***

| Parameter Name | Measurement Protocols/Classifications |
|---|---|
| **LLID** | Unique identifier for stream given in the detailed 1:24K USGS NHD layer |
| **Name** | Name of the inventoried stream. |
| **ReachID** | Unique identifier given to each inventoried reach of stream, per year of photo assessed. ReachID will be an alphanumeric code, consistent per stream (i.e. GALL99-01 for Gallatin River 1999 photo, reach 1). The ReachID will be the common link to the other assessment tables. |
| **PhotoDate** | The date of the photo from which the reach was designated. |
| **Segment_From** | The beginning length measurement of the specified stream reach. Measured in GIS from the route length assigned to the modified high resolution NHD layer (Orthophoto base map used to locate points as close as possible to same point on aerial photograph). |
| **Segment_To** | The end of the reach length as measured in GIS using the modified high resolution NHD layer. |

***Table 2-2. Channel Parameters***

| Parameter Name | Measurement Protocols/Classifications |
|---|---|
| **ReachID** | Unique reach identifier that relates to the reach table and ultimately to the modified high resolution NHD layer. |
| **Active_Ch (feet)** | The active channel width (channel width at bankfull). |
| **Confinement** | Channel Confinement -<br>**U =** Unconfined: floodplain width > 4X bankfull width<br>**M** = Moderate: floodplain width 2X to 4X bankfull width<br>**C** = Confined: floodplain width < 2X bankfull width |
| **RLength (feet)** | The linear length of the specified stream reach. Measured on the aerial photo to the nearest foot using a planimeter. |
| **VLength (feet)** | The linear length of the valley adjacent to the specified stream reach. Measured on the aerial photo to the nearest foot using a planimeter. |
| **Sinuosity** | Sinuosity of the stream segment as measured from an aerial photograph. This should be measured using the same contour interval locations as used on the topographic map for valley slope. Equation: stream length in feet / valley length in feet. |
| **ValleyGrade (percent)** | Slope of the valley type as measured between contour intervals from the topographic map. Equation: change in elevation in feet / distance in feet. |
| **StreamGrade (percent)** | Slope of the stream segment as defined for valley slope. Equation: valley slope / sinuosity |
| **ValleyType** | Valley classification based on Rosgen's classification. **I, II, III, IV, V, VI, VII, VIII, IX, X, XI** |
| **Rosgen1** | Rosgen Level I stream channel classification based on channel slope, sinuosity, valley type, and stream pattern and form. **A**, **Aa+**, **B**, **C**, **D**, **Da, E**, **F**, **G**. |
| **RosgenPotential** | Expected level I Rosgen stream channel type (if reach has been altered). |

### *Table 2-2. Channel Parameters*

| Parameter Name | Measurement Protocols/Classifications |
|---|---|
| **Notes** | Important channel observations not captured by other table fields. |

### *Table 2-3. Riparian Parameters*

| Parameter Name | | Measurement Protocols/Classifications |
|---|---|---|
| **ReachID** | | Unique reach identifier that relates to the reach table and ultimately to the modified high resolution NHD layer. |
| **LB_RBW** | | Left bank riparian belt width. Average horizontal width of left bank riparian vegetation. Buffers are measured from the channel edge to a maximum of 300 ft. If a road is encountered, it is considered the edge of the riparian belt. |
| **RB_RBW** | | Right bank riparian belt width. Average horizontal width of right bank riparian vegetation. Buffers are measured from the channel edge to a maximum of 300 ft. |
| **PercentLB_RBW** | | Percent of left bank reach length exhibiting the described buffer width. |
| **PercentRB_RBW** | | Percent of right bank reach length exhibiting the described buffer width. |
| **VegCoverClass** | **CW** | Existing type of riparian vegetation estimated as a percentage for each cover class along the reach.<br>**CW** = Cottonwoods (Deciduous)/woody shrubs<br>**WS** = Willows/woody shrubs<br>**CN** = Conifers/woody shrubs<br>**HB** = Herbaceous; whereby, the grasses or forbs are being grown into the riparian and almost no woody vegetation is present.<br>**BD** = Bare/disturbed ground<br>**IP** = Impervious cover (roadway, parking lots, concrete, pavement, roofs/buildings, etc...) |
| | **WS** | |
| | **CN** | |
| | **HB** | |
| | **NV** | |
| **Bank Stability** | | Existing bank conditions estimated as a percentage along the reach.<br>**H** = High. No erosion observed.<br>**M** = Moderate. Erosion observed is associated with meander bends.<br>**L =** Low. Extensive erosion associated with channel migration or channel widening. |
| **Bank Stability Source** | | **A** = Anthropogenic<br>**N** = Natural |
| **Riparian Health** | | **E** = Excellent. High bank stability along >80% of reach. Riparian belt width exceeds 50 feet on both sides of the stream along >80% of the reach, excluding areas that are naturally confined.<br>**F** = Fair. Moderate to high bank stability along >60% of reach. Riparian belt width exceeds 50 feet on both sides of the stream along >60% of reach, excluding areas that are naturally confined.<br>**P** = Poor. Low bank stability along >40% of reach. Riparian belt width is less than 50 feet on both sides of the stream along >40% of the reach, excluding areas that are naturally confined. |
| **Shading** | | The potential for riparian vegetation to provide shade over the channel.<br>**H** = High. Greater than half of the channel is shaded during the day.<br>**M** = Medium. About half to one quarter of the channel is shaded during the day.<br>**L** = Low. Less than a quarter of the channel is shaded during the day. |
| **Notes** | | Important riparian observations not captured by other table fields.<br>For instance, notes on the suspected causes of unstable banks. |

***Table 2-4. Source Parameters***

| Parameter Name | Measurement Protocols/Classifications |
|---|---|
| **ReachID** | Unique reach identifier that relates to the reach table and ultimately to the modified high resolution NHD layer. |
| **LandUse** | Adjacent Land Use<br>**SLV** = Silviculture<br>**FOR** = Forest lands, other than timber harvest lands<br>**GRZ** = Grazing<br>**MN** = Mining<br>**AG** = Irrigated or cultivated agricultural lands<br>**RF** = Ranch facilities<br>**GC** = Golf course<br>**VBR** = Valley bottom recreation areas<br>**HSR** = Hillslope recreation areas<br>**LR-SW** = Low intensity residential, sewer system<br>**LR-SP** = Low intensity residential, septic system<br>**HR-SW** = High intensity residential, sewer system<br>**HR-SP** = High intensity residential, septic system<br>**URB** = Urban infrastructure and facilities<br>**TCP** = Transportation corridor, paved<br>**TCU** = Transportation corridor, unpaved |
| **LandOwnership** | Adjacent Land Ownership<br>**PV** = Private<br>**FS** = Forest Service<br>**BLM** = Bureau of Land Management<br>**MT** = State of Montana |
| **Irrigation Flow** | Known or observable diversions or points of return flow. **IN** = flow is returning to the stream; **OUT** = flow is removed from the stream. |
| **Source1** | Selection from a dropdown list of the US EPA's permissible reporting values (http://www.epa.gov/waters/reporting/source_lut.html) |
| **Source2** | Selection from a dropdown list of the US EPA's permissible reporting values (http://www.epa.gov/waters/reporting/source_lut.html) |
| **Source3** | Selection from a dropdown list of the US EPA's permissible reporting values (http://www.epa.gov/waters/reporting/source_lut.html) |
| **Source4** | Selection from a dropdown list of the US EPA's permissible reporting values (http://www.epa.gov/waters/reporting/source_lut.html) |
| **Source5** | Selection from a dropdown list of the US EPA's permissible reporting values (http://www.epa.gov/waters/reporting/source_lut.html) |
| **Source6** | Selection from a dropdown list of the US EPA's permissible reporting values (http://www.epa.gov/waters/reporting/source_lut.html) |
| **Source7** | Selection from a dropdown list of the US EPA's permissible reporting values (http://www.epa.gov/waters/reporting/source_lut.html) |
| **Source8** | Selection from a dropdown list of the US EPA's permissible reporting values (http://www.epa.gov/waters/reporting/source_lut.html) |
| **Source9** | Selection from a dropdown list of the US EPA's permissible reporting values (http://www.epa.gov/waters/reporting/source_lut.html) |
| **Source10** | Selection from a dropdown list of the US EPA's permissible reporting values (http://www.epa.gov/waters/reporting/source_lut.html) |
| **Notes** | Important source observations not captured by other table fields. |
| **Notes_2** | Important source observations not captured by other table fields. |
| **Notes_3** | Important source observations not captured by other table fields. |
| **Notes_4** | Important source observations not captured by other table fields. |
| **Notes_5** | Important source observations not captured by other table fields. |

The product will be the generation of a report reviewing the aerial photograph assessment (GIS-aided inventory) of the 303(d)-listed stream segments. The report will summarize key findings for each water body on a reach-specific basis. Existing conditions and potential sources of impairment will be discussed. Specific effort will be made to stratify the stream reaches into similar categories of Rosgen stream type, riparian vegetation, land-use, and land ownership. This stratification will aid the future field assessment efforts of the source assessment, as well as potential modeling efforts (reference conditions, impairment determinations). Data tables, maps, and GIS data will accompany the report and will be used to summarize key findings. The information generated from this project will provide the basis for completing the Upper Gallatin River TMDL restoration plan.

## 2.2 Assessment Methods Requirements

The aerial photograph assessment will be conducted with the use of a stereoscope, light table, scale, and digitizing planimeter. Digital 1:24,000-scale USGS topographic maps and one-meter resolution orthophoto quadrangle maps will be assembled in a GIS to aid with the photo measurements, data interpretation, and geodatabase creation. Table 2-5 details the resolution and source for measurements made during the aerial photograph interpretation.

**Table 2-5. Resolution Level and Source for Measured Parameters**

| Assessment Parameters | Measurement Increments | Data Input | Source of Measurement |
|---|---|---|---|
| Segment_From | 0.01 ft. | 0 to measured end of stream | GIS; measured on the modified high resolution NHD layer |
| Segment_To | 0.01 ft. | 0 to measured end of stream | GIS; measured on the modified high resolution NHD layer |
| Active_Ch | 5 ft. | 5, 10, 15, 20, 25, 30, 35, 40, 60, 80, 100, 120 | aerial photos; measured & estimated |
| RLength | 1 ft. | whole number | aerial photos; measured |
| VLength | 1 ft. | whole number | aerial photos; measured |
| Sinuosity | 0.01 | 0.01 | Stream length / Valley length (measured; aerial photo) |
| ValleyGrade | 0.001 | 0.001 | ▲ Elevation / Valley length (measured; topographic map) |
| StreamGrade | 0.001 | 0.001 | Valley slope / Sinuosity (measured; topographic map and aerial photo) |
| LB_RBW & RB_RBW | 10 ft. | 1 – 300 ft or > 300 ft | aerial photos; measured |
| PercentLB_RBW & PercentRB_RBW | 10% | decimal percent; if <10% then 0. | aerial photos; estimated |

## 2.3 Instrument Calibration, Testing, Inspection, and Maintenance

All analytical instruments and equipment will be maintained in proper working order, with regular maintenance being performed as required by the manufacturer. Prior to use, personnel will inspect the equipment to make sure it is in proper working order. Maintenance notes will be

entered in an equipment logbook. Planimeter calibration will be performed at the beginning and end of each day of use. Calibration will consist of measuring a known distance three times and checking for accuracy. Calibration notes will be entered into the equipment logbook.

### 2.4 Non-Direct Measurements

Non-direct measurements for the aerial photograph assessment include the use of GIS layers to identify potential sources, previously collected data in the Upper Gallatin Watershed relevant to the aerial photograph assessment, or any data not directly resulting from the procedures described in this QAPP. All non-direct measurements must be evaluated to determine compliance with measurement quality objectives before acceptance.

### 2.5 Data Management

Data generated during the aerial photograph assessment and reach inventory will be stored in GIS shapefiles and the aerial photograph geodatabase. PBS&J project staff will submit all project data to the Montana Department of Environmental Quality (DEQ) in digital formats (MS Word, MS Excel, ESRI ArcGIS, etc.) following QA/QC procedures to screen for data entry errors, etc. GIS data will be accompanied with FGDC metadata files. These data will be included in the final narrative interpretive report. All data generated during this project will be stored at PBS&J's Helena office, and will be made available to the public.

## 3.0 QUALITY ASSURANCE OVERSIGHT PROCESS

### 3.1 Quality Assurance Review Process

The primary mechanism through which project measurement quality objectives (MQOs) will be met is prevention. Planning and design of the project, documented instructions and procedures, and use of qualified and experienced personnel as outlined in this QAPP are expected to prevent most problems associated with data quality or quantity.

An assessment program will be used to identify any problems with the project data and trigger response actions to bring the data back in line with the project MQOs. The assessment will include routine evaluation of the data with respect to MQOs such as precision, accuracy, and completeness, as presented in **Section 1.5**. The assessment will also include a structured data validation process, as discussed in **Section 4.0**. Assessment may include high-level monitoring of certain project activities or audits initiated as a response action (discussed below).

### 3.2 Quality Assurance Response Actions

In the event that the assessment program identifies problems with project data, response actions will be triggered. The nature of these actions will depend upon the severity and types of problems encountered, and will begin with a review of project procedures related to the identified problem(s). Additional costs to the assessment program may incur if response actions are triggered. The project manager must approve these additional costs before response actions commence. Additional response actions may include:

- **Preventive Response Actions**
  These measures would be directed at preventing the identified problem from being repeated, and include:
  - implementation of high-level monitoring of project activities associated with the problem to prevent further deviations; and
  - initiation of a system of audits that will include random and unannounced evaluations of personnel, or equipment to determine if procedures outlined in the QAPP are being adhered to. The project manager will be responsible for implementing corrective measures to address identified deviations from the QAPP.

- **Corrective Response Actions**
  These measures will result in a correction of the problem and replacement of the problematic data with data that meet the project MQOs. Potential corrective actions include:
  - re-measuring if the problem is related to analysis procedures.

## 4.0 DATA VALIDATION

### 4.1 Data Review Process

Data will be reviewed at the end of each phase through the detailed examination of raw data to check for calculation and transformation errors, measurements within instrumentation range, and data entry errors. Various computer software programs, including Microsoft Excel, may be used to assist in the data review process to help identify potentially erroneous data.

### 4.2 Data Verification and Validation

Data verification refers to the routine checks the photo analyst conducts in ensuring that the QAPP is followed. At a minimum, data verification will include evaluation of assessment documentation/ representativeness, instrument calibration and tuning.

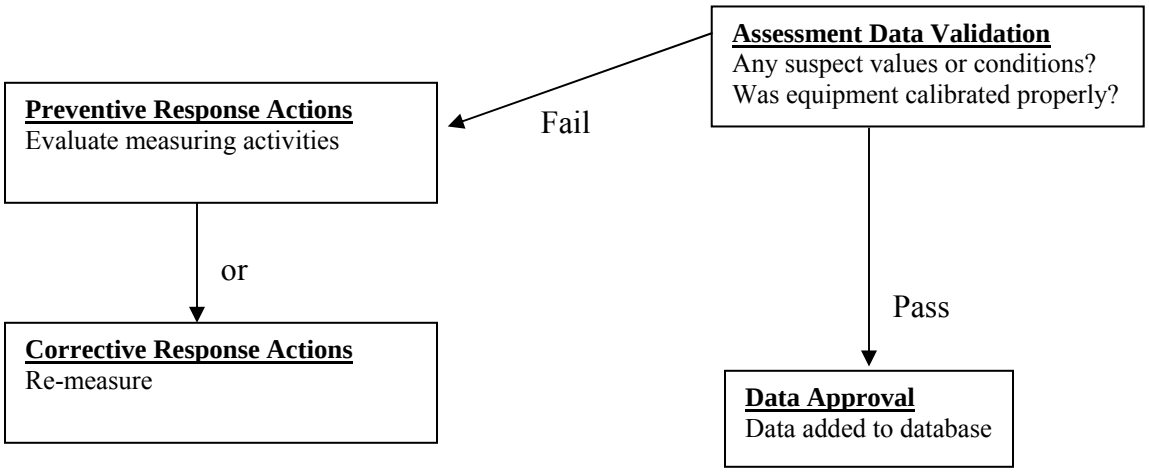
### 4.3 Data Validation Feedback Mechanism

Data validation refers to the confirmation by examination and provision of objective evidence that the particular requirements for the intended use of data have been met. Data validation is conducted on verified data and the methodology will differ for each parameter according to the project MQOs. All incoming data must pass the validation process before entry into the database. Data that fail the validation process will be qualified and flagged as such or, in extreme cases, excluded from the database. Identification of invalid data will trigger preventive or corrective response actions. At a minimum, the validation process will address the following:

- Assessment data will be reviewed, and anomalous or suspect values will be noted and an explanation provided.

A flow chart describing the data validation process is provided in **Figure 4-1**.

**Figure 4-1.** ***Data Validation Process***




## 5.0 QUALITY ASSURANCE PROJECT PLAN IMPLEMENTATION

### 5.1 Review and Approval Process

This QAPP is to be distributed to all personnel and organizations listed on the distribution list. All personnel involved in the Upper Gallatin Watershed aerial photograph assessment and reach inventory are to sign and date the Approval section of this document and return the signed portion to the project manager. By signing the Approval section, the signatory agrees that he/she has read and understands his or her role in the monitoring program, and will adhere to all sections of this QAPP. Additionally, all personnel involved in the project should retain or have access to the current version of this QAPP.

### 5.2 Review and Revision Process

This QAPP will be reviewed by the project manager upon the adoption of changes to the program. Any modifications to this QAPP will require formal approval.

## 6.0 REFERENCES

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