SECTION 5

PROBLEM DEFINITION/BACKGROUND; PROJECT DESCRIPTION

5.1 The specific problem to be solved or decision to be made is stated in the problem definition. Sufficient background information should be included to provide a historical perspective articulating the regulatory or alleged toxic exposure situation that led to the need for the project. The past history and problem situation should include any previous work or data as well as any regulatory or legal elements that will allow a technically-trained reader to understand the project objectives.

5.2 The purpose of the project description is to define the specific objectives of the bioassessment project and describe how the project will be designed to obtain the information needed to accomplish the project goals and uses. As this section supplies information needed by the intended users of the data, the project description should include a general overview, study/monitoring design features and rationale (methods for selecting sampling station locations, sampling period, etc.), and project timetable.

5.2.1 The general overview contained in the project description should include, at a minimum, the following information:

- statement of problem, decision, or specific questions to be resolved;
- description of the study site, facility, process, or operating activities to be evaluated;
- applicable technical, regulatory, or program-specific quality standards, criteria, or objectives;
- requirements for any special personnel or equipment;
- the assessment tools needed for the project (i.e., program technical reviews, peer reviews, and technical audits as needed and/or specified by the Quality Assurance Plan (QAP);
- anticipated uses of data to answer questions and make decisions;
- the consequences of Type I or Type II errors based on these results;
- historical conditions, existing datasets.

5.2.2 Evaluation of Historical Datasets

Previous projects that provide information on habitat, biota, or methods should be evaluated. Such evaluation can give invaluable guidance in study design, including sampling gear and study site selection. Use of comparable design, gear, site location, and index period can considerably strengthen the temporal component of an ecological study. Aspects of historical datasets evaluated include (but are not limited to):

- sample types (assemblage, physical habitat assessment, accompanying water/sediment chemistry)
- dates of sample collection
- location of sampling sites
- type of sampling gear
- intensity of laboratory processing (taxonomy, sorting).

5.3 The study/monitoring design features should be described and should include the following:

- A list of all measurements or variables to be taken (e.g., assemblage metrics, physical and biological habitat parameters, or water chemistry variables), including a designation of which measurements are critical versus non-critical to the accomplishment of project goals. It should be noted that many biological metrics and parameters will undergo revision and fine tuning after evaluations of pilot studies and/or reevaluation of their effectiveness for the program; these revisions can be appended to the overall program QAPP until the next annual review and revision.

- A statement of how measurements will be evaluated; e.g., by comparison to reference data, literature, models, internal statistical properties, or other historical information. If statistics are used to analyze data, the rationale used to select the statistic should be stated.

- Explicit delineation of ecosystems to which decisions will be applied, and a summary table listing the following for each sampling station:
  - types of samples (benthos, fish, periphyton, plankton, physical and biological habitat assessment, or water quality)
  - numbers of samples of each type (designate primary and quality control)
  - sampling gear.

5.4 A project timetable is included with beginning and ending dates for the general project and for specific activities within the project. Any constraints, such as seasonal variations in biota or stream flow, sampling logistics or site access, should be identified in the timetable. The timetable needs to be detailed yet flexible to account for unanticipated problems such as bad weather; guidance should be included for handling such problems.

SECTION 6

QUALITY OBJECTIVES FOR MEASUREMENT DATA

6.1 The QAPP must include a statement of the project's Data Quality Objectives (DQOs). DQOs are qualitative and quantitative statements developed by data users, at the programmatic, project and measurement levels, to specify the quality of data needed to support specific decisions. Data users include representatives from public or private sectors, stakeholders, and managers.

The logic process related to DQO development is made up of several of the components of the project description outlined previously in Section 5. DQOs encompass all aspects of data collection, analysis, validation, and evaluation. The DQO process provides a means of ensuring the required confidence level in the data needed by decisionmakers.

Evaluation of candidate measurement parameters (indicators) relative to stated selection criteria (Table 6-1) ensures linkage of the decision process to DQOs. The process involves establishing the allowable uncertainty of a data set which may lead to Type I or Type II errors: false positives (a problem is found to exist when in fact it does not) and false negatives (a problem is not found when in fact it does exist). The acceptance probabilities of those errors as established by decisionmakers are the DQOs. The DQO process entails establishing action-triggering values and selecting rates of false positive and false negatives that are acceptable to the decisionmaker.

The quality of a particular data set is a measure of the types and amount of error associated with the data. Data quality is described by qualitative and quantitative parameters, including precision, accuracy, representativeness, completeness, comparability, and sensitivity—all included in the QAPP. The seven steps of the DQO process are in Figure 6-1.

TABLE 6-1 Summary of some measurement (indicator) selection criteria.

CRITERIA/QUALITY	DEFINITION(S)
Scientific Validity (Technical Considerations)	
Measurable/ Quantitative	Feature of environment measurable over time; has defined numerical scale and can be quantified simply.
Sensitivity	Responds to broad range of conditions or perturbations within an appropriate timeframe and geographic scale; sensitive to potential impacts being evaluated.
Resolution/ Discriminatory Power	Ability to discriminate meaningful differences in environmental condition with a high degree of resolution (high signal : noise ratio).
Integrates Effects/ Exposure	Integrates effects or exposure over time and space.
Validity/Accuracy	Parameter is true measure of some environmental condition within constraints of existing science.
	Related or linked unambiguously to an endpoint in an assessment process.
Reproducible	Reproducible within defined and acceptable limits for data collection over time and space.
	Sampling produces minimal environmental impact.
Representative	Changes in parameter/species indicates trends in other parameters they are selected to represent.
Scope/Applicability	Responds to environmental changes on a geographic and temporal scale appropriate to the goal or issue.
Reference Value	Has reference condition or benchmark against which to measure progress.
Data Comparability	Can be compared to existing datasets/past conditions.
Anticipatory	Provides an early warning of changes.
Practical Considerations	
Cost/Cost Effective	Information is available or can be obtained with reasonable cost/effort.
	High information return per cost.
Level of Difficulty	Ability to obtain expertise to monitor.
	Ability to find, identify, and interpret chemical parameters, biological species, or habitat parameter.
	Easily detected.
	Generally-accepted method available
Programmatic Considerations	
Relevance	Relevant to desired goal, issue, or agency mission (e.g., fish fillets for consumption advisories; species of recreational or commercial value).
Program Coverage	Program uses suite of indicators that encompass major components of the ecosystem over the range of environmental conditions that can be expected.
Understandable	Indicator is or can be transformed into a format that target audience can understand (e.g., nontechnical for public).

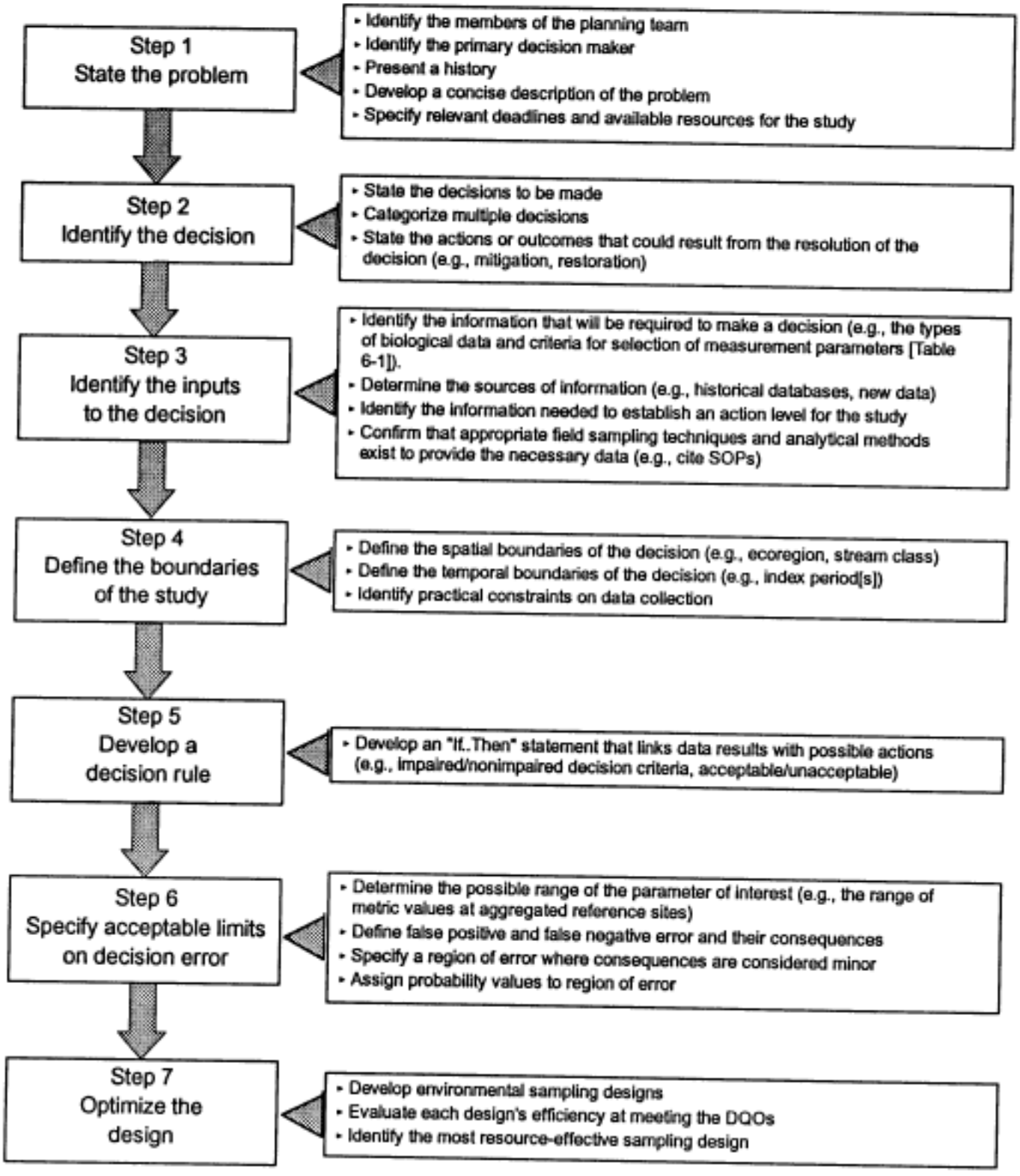

FIGURE 6-1 The seven step DQO process.

6.2 The scope of the project should be described (e.g., the geographic locale, environmental medium, time period, etc.), and any constraints such as time (index period) or resources.

6.3 Sources of error or uncertainty associated with variables and indicators should be evaluated in pilot studies and include:

- measurement error: the difference between sample values and *in situ* true values;
- analytical error: error associated with the measurement process;
- sampling error: a function of natural spatial and temporal variability and sampling design (non-measurement error);
- sources such as collection, handling, storage, and preservation.

QA activities and QA documentation procedures described in this guide are intended to assist in reducing the magnitude of these sources and their frequency of occurrence.

6.4 The uncertainty component of a multimetric index can be represented by the range of values from aggregated reference sites. The values are either individual metric values or total bioassessment scores calculated from X number of reference sites within a stream class. Reference sites are selected based on the concept of minimal anthropogenic disturbance, their being typical for the ecoregion, subecoregion, and waterbody type, or their potential for consideration as a natural landscape (Hughes 1995; Hughes et al. 1994). Repeat sampling within the same index period from year to year will address natural interannual variability which can be useful for evaluating uncertainty.

Expression of uncertainty is difficult when there is insufficient statistically-valid measurements. Costanza et al. (1992) have developed a data-quality grading system intended to allow statements of uncertainty on data ranging from quantitative measurements to informed guesses. The approach is a notational system that attaches a five-part description of data quality to datasets, including numeric, unit, spread, assessment, and pedigree; it is introduced in this document to help fill a gap in the ability to report confidence in environmental measurements.

Measurement Quality Objectives

6.5 For each major measurement or value, the QA objectives for precision, representativeness, comparability, accuracy, and completeness (measurement quality objectives or MQOs) should be presented. These features are defined in Smith et al. (1988) and USEPA (1989).

6.6 Precision is a measure of mutual agreement among individual measurements or enumerated values of the same property of a sample, usually under demonstrated similar conditions.

Assuring consistency of sampling and sample processing, and striving for repeatability of measurements (Platts et al. 1983) will increase the precision of data. For example, take replicate samples at adjacent sites where different assessment results are not expected (due to the apparent absence of additional stressors) and measure the precision of the procedure. Precision, representativeness, and comparability can also be compared using raw data, metric index values, and, possibly, final bioassessment scores. Appropriate methodology and adequate training and instruction of personnel in methods application is the most certain way to ensure consistency, repeatability, and precision.

6.7 If precision is to be calculated from two replicate samples, use Relative Percent Difference (RPD) calculated as

$$RPD = \frac{(C_1 - C_2) \times 100}{(C_1 + C_2) \div 2}$$

where C_1 = the larger of the two values and C_2 = the smaller of the two values. And, if it is to be calculated from three or more replicate samples, use Relative Standard Deviation (RSD) calculated as

$$RSD = \frac{s}{\bar{X}} \times 100$$

where s = standard deviation and $\bar{x}$ = mean of replicate samples. The standard deviation or the standard error of a sample mean (s) is calculated as

$$S=\sqrt{\sum_{i=1}^{n}\frac{(X_1-\bar{X})^2}{n-1}}$$

where x_i = measured value of the replicate, $\bar{x}$ = mean of replicate sample measurements, n = number of replicates. Precision can also be expressed in terms of the range of measurement values.

6.8 Data representativeness is the degree to which data accurately and precisely represent a characteristic of a population or community, natural variability at a sampling point, or an environmental condition. Representativeness of a sample depends largely on randomized sampling of the target assemblage (Green 1979; Smith et al. 1988; Freedman et al. 1991) and therefore is highly dependent on the sampling program design. Generally, the sampling program should be designed to ensure representative sample collection of the habitat or population being sampled and adequate sample replication. The original Rapid Bioassessment Protocols (RBPs) (Plafkin et al. 1989) were developed primarily for higher gradient streams with a predominance of riffles, which are considered to be the most biologically-productive habitat in such streams. However, in streams that are in a lower-gradient topography (as in many coastal plains and deltaic zones), there is often a lack of riffles. The Mid-Atlantic Coastal Plains Streams Workgroup has developed a multihabitat sampling procedure for that area (MACS 1993, draft). For example, for collection of benthic macroinvertebrates in low gradient (primarily non-riffle) streams using the 20-jab dipnet collection method, the sampling would focus on representative sampling reach characteristics. That is, if the suitable sampling habitat within the sampling reach consisted of 70 percent snags, 20 percent banks/ shorezone vegetation, and 10 percent submerged macrophytes, the collection effort would comprise 14 snags, four banks, and two submerged macrophytes. Representativeness is, in part, addressed by the description of the sampling techniques and the rationale used to select the sampling locations. Sampling techniques should be verified and validated in separate studies (Section 10).

6.9 Comparability is a measure of the confidence with which one data set can be compared to another. It is often described in non-quantitative terms, but must be considered in designing the sampling plans, index period, critical habitat characteristics, topographic, geological, and hydrogeologic information, analytical methodology, quality control, and data reporting. The use of standardized sampling techniques and USEPA-approved analytical methods enhances the comparability of parameters being measured with data similarly generated from

other sources. Reporting of data in units used by other organizations improves comparability. For biological assessments, comparability of data would need to be determined by classifications such as ecoregion (or smaller geographic unit), index period, and sampling gear. For example, samples collected within the same ecoregion using the same gear but collected during different seasons (index periods) may not be comparable.

6.10 Completeness is defined as the percentage of measurements made that are judged to be valid according to specific validation criteria and entered into the data management system. To achieve this objective, every effort is made to avoid sample and/or data loss through accidents or inadvertence. Accidents during sample transport or lab activities that cause the loss of the original sample will result in irreparable loss of data. Collection of sufficient samples allows reanalysis in the event of an accident involving a sample. The assignment of a set of continuous (serial) laboratory numbers to a batch of samples which have undergone chain-of-custody inspection makes it more difficult for the technician or taxonomist to overlook samples when preparing them for processing and identifications. The laboratory serial numbers also make it easy during the data compilation stage to recognize if some samples have not been analyzed.

6.11 Percent completeness (% C) for all measurements can be defined as follows (USEPA 1989):

$$\%C = \frac{v}{T} x100$$

Where v = the number of measurements judged valid and T = the total number of measurements.

6.12 Table 6-2 provides hypothetical examples of MQOs for precision and completeness. For example, when comparing two samples to determine precision, a relative percent difference of 50% of the number of individuals (benthos) may be an acceptable difference depending on the objectives and MQOs stated for the project. Data quality requirements should be based on prior knowledge of the sampling procedure or measurement system by use of replicate analyses, reference conditions (site-specific or ecoregional), or requirements of the specific project (USEPA 1989).

TABLE 6-2 Example summary table of some hypothetical data quality requirements.

MEASUREMENT PARAMETER	REFERENCE METHODS	PRECISION (e.g., RPD)	COMPLETENESS (%)
Benthos			
No. individuals	Plafkin et al. 1989	50	95
No. taxa		15	95
Fish			
No. individuals	Karr et al. 1986	25	95
No. species		15	95

DQOs that cannot be expressed in terms of precision, accuracy, or comparability should be reported by describing the specified method that will satisfy all regulatory requirements specified; all other QAPP requirements would still need to be fulfilled.