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Technical Papers

Project Planning & Assessment

- M.Messner, Data Quality Objectives for Atrazine Monitoring - 3:00 PM
- I.Salau, Challenges of Implementing Project-Level QA for Environmental Projects in Developing Countries - 3:30 PM
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Data Quality Objectives for Atrazine Monitoring

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Abstract

This paper describes an EPA team's deliberations and outcomes as they "walked through" the seven-step Data Quality Objectives process. The process begins with problem definition, expressing concerns about human health and the cost of drinking water treatment, and ends with statistical evaluation of the current strategy. A variety of occurrence patterns are identified, modeled, and used to estimate noncompliance probabilities as functions of long-term average atrazine concentration.

Background

To familiarize itself with the DQO process and assess its utility in rulemaking, a team of scientists in EPA's Office of Ground Water and Drinking Water attempted to apply the process using the Atrazine rule as a model. This paper describes the team's experience with the process. In this exercise, the team acted as though it were crafting the original atrazine drinking water regulation in the early 1990s. Our purpose was two-fold; first, to understand how the current strategy performs (correctly identifying systems as either in or out of compliance) and second, to gain some familiarity with the DQO Process. We hoped to learn how the process could be used in the guiding the design of broadly-applied monitoring strategies.

STEP 1 – State the Problem

Our team acted as though it was back in time, to the early 1990s, when the Atrazine rule was being developed. In the early 1990s, atrazine was classified a possible human carcinogen. We wanted to play the role of an EPA team, considering how to best regulate atrazine in drinking water.

We decided to think in terms of a public water system serving a community of moderate size (25,000). Of course, the atrazine regulation applies to systems that are significantly smaller and others that are significantly larger than this. We would like our strategy to be capable of indicating whether the atrazine level in drinking water (a.k.a., finished water) is acceptable.

STEP 2 – Identify the Decision

The larger decision is how to regulate atrazine, but we handled the problem by focusing on the decision for our moderately sized community. The principle question for the community is this: "Is atrazine in our drinking water at a safe level?" The alternative actions available to them are (a) continue monitoring if the water seems to be safe and (b) start using activated carbon to reduce exposures if the water seems to be unsafe.

STEP 3 – Identify Inputs to the Decision

Inputs to the decisions will include new measurements of atrazine in the finished water and an action level, the Maximum Contaminant Level.

We already have in hand a monitoring schedule (quarterly), the statistic of interest (the running annual average, computed every quarter), and the action level (.003 mg/L). Alternatives would be considered in a real rule development process, but we decided to accept these features of the inputs.

STEP 4 – Define the Boundaries of the Study

The target population of interest is the entire volume of finished water that is produced by the system, over a period of at least several years. Since the cancer is a chronic health effect, the period of exposure is long term and therefore, lifetime exposure is of concern. However, since residents' lives span different lifetimes, we simply want to understand the long-term average concentration. Spatial boundaries are the limits of the water distribution system. Because atrazine levels are expected to neither increase nor decrease significantly once in the system, we can limit the location of sampling to the treatment plant effluent stream.

Since health effects are the results of lifetime exposures, there is no health-based reason to panic. Decisions should be made within a calendar quarter of discovering the problem.

STEP 5 – Develop a Decision Rule

The rule: If a running annual average atrazine concentration exceeds the MCL, then (a) the system will be declared out of compliance with the standard, (b) the public will be notified, and (c) the system will need to take action, such as start using activated carbon, to reduce exposures.

STEP 6 – Specify Tolerable Limits on Decision Error

Lifetime exposure at the atrazine MCL is considered to convey negligible cancer risk. To maintain average levels below the MCL, some treatment systems may need to remove atrazine by using some form of activated carbon.

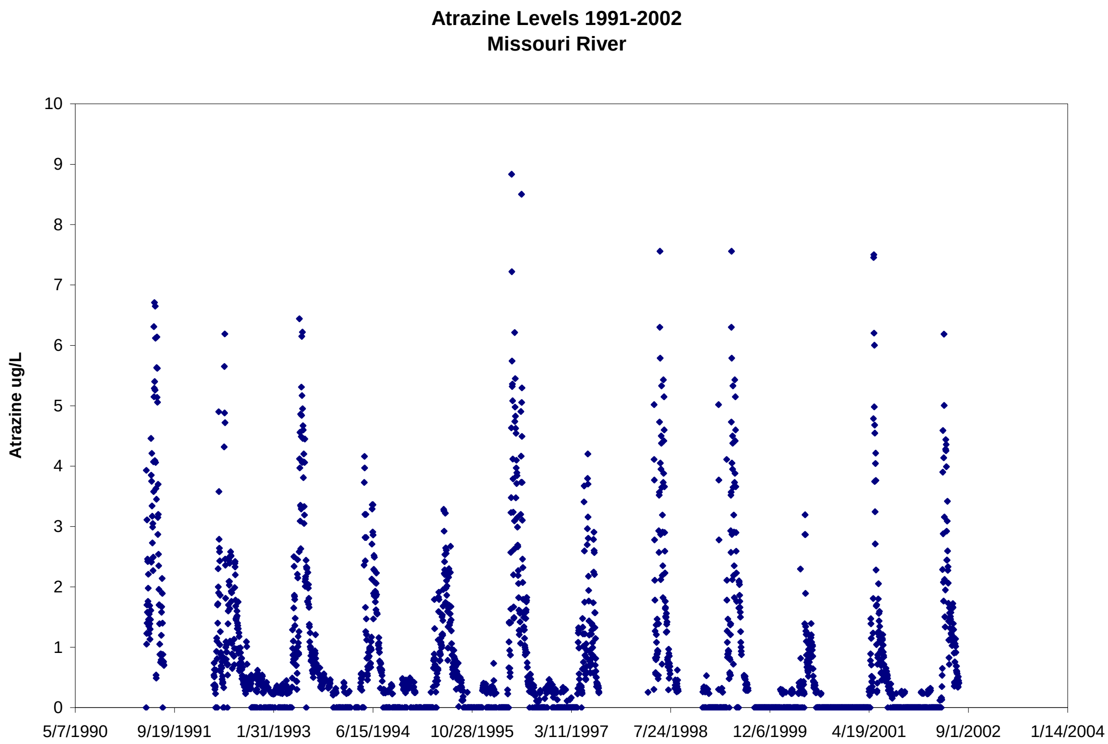
We are concerned with two kinds of decision error. A Type I or false positive error occurs when long-term average concentration is at most equal to the MCL, but the average compliance measurement for a year exceeds the MCL. A Type II or false negative error occurs when the long-term average concentration exceeds the MCL, but the average compliance measurement for a year is not greater than the MCL. Expressing little concern about either "error" when the true average is very near the MCL, the team focused on situations where the true long-term average is (a) half the MCL, or 1.5 μg/L, for the false positive and (b) double the MCL, or 6 μg/L, for the false negative. The table below highlights the consequences of concern for these errors.

Consequences of Type I Error (False Positive)	Consequences of Type II Error (False Negative)
Deciding MCL is exceeded when the true long-term average concentration is 1.5 μg/L (half the MCL) • Cost to system (GAC or PAC) • Lost confidence in water utility and quality of drinking water • Improved finished water taste and odor with removal of other contaminants • Reduced atrazine exposure	Deciding MCL is NOT exceeded when the true long-term average concentration is 6 μg/L (double the MCL) • Increased lifetime cancer risk due to atrazine (at least until MCL is exceeded in future) • Lower treatment cost (no GAC, PAC)

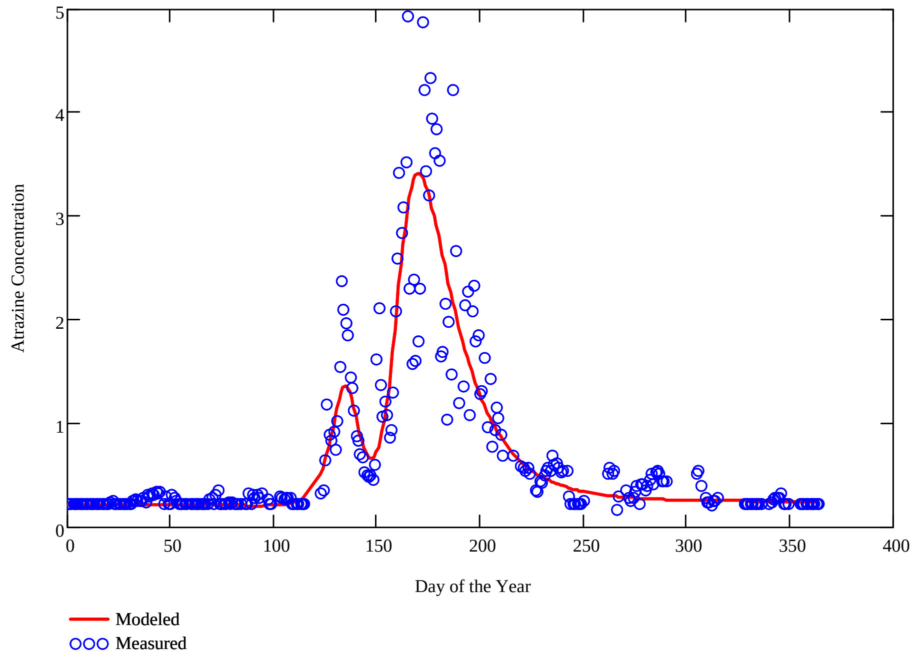
The team expressed greatest concern for the first consequence listed above for the Type II error: increased lifetime cancer risk. This concern was reduced somewhat, when the team considered the likelihood of detecting the problem in subsequent years. Considering all these concerns, and recognizing that a design was already in place, the team decided to look at the design's performance before establishing quantitative limits on the two kind of decision errors. If we had actually been selecting a design, it would have been more important to quantify these limits before exploring design options.

STEP 7 – Optimize the Design for Obtaining Data

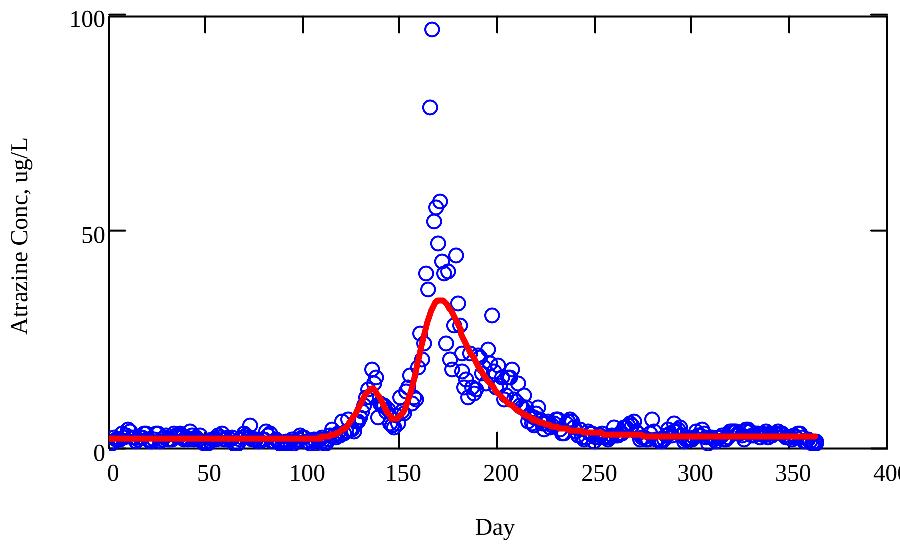
Atrazine is primarily used early in the growing season for corn and other crops. When heavy rains follow immediately after application, runoff concentrations can be very high, but only for short periods of time (days). Surface waters with high average atrazine levels tend to have the most "spiky" occurrence, while waters with low levels (averages less than 1 μg/L) exhibit low variability. The high-variability pattern shown in the graph below is typical of waters with high average concentrations.



EPA used a nonparametric artificial neural network (ANN) model to fit the 1993 data from this source water (Missouri River). Maximum likelihood parameters were identified, assuming lognormal error with autocorrelation. The figure below shows the resulting best-fit ANN function agrees well with the 1993 data:



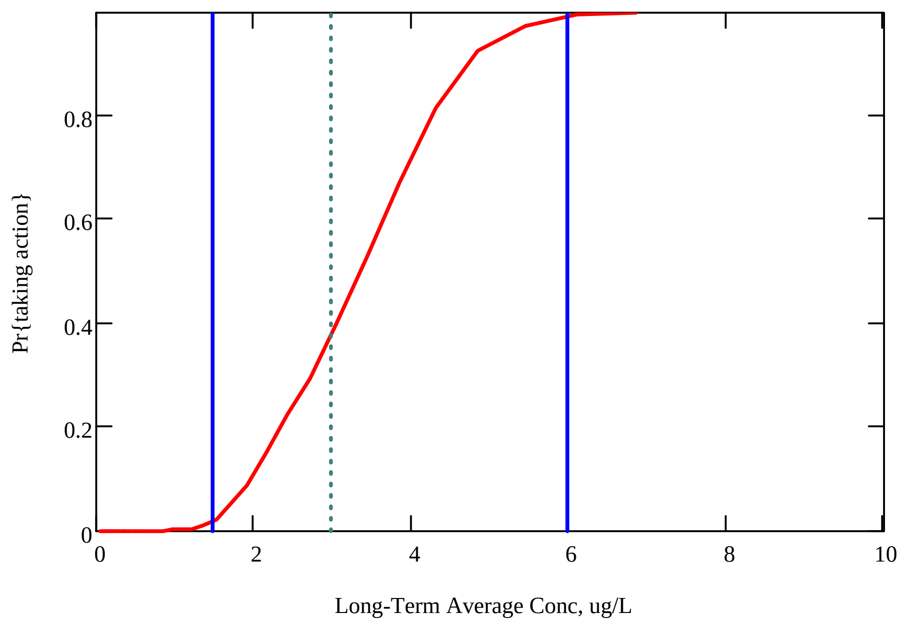
Given the maximum likelihood model (with its autocorrelation and lognormal error structure), the long-term average concentration is 0.67 µg/L. By including a multiplicative scale factor, the occurrence pattern can be adjusted to simulate source water with any desired long-term average concentration. The figure below shows simulated daily data associated with a mean concentration of 6.7 µg/L.



Finally, it was a simple matter to simulate the grabbing of single quarterly measurements, comparing with the MCL and observing how often the MCL was exceeded. The figure below shows how the probability of noncompliance increased with long-term average concentration.

The performance diagram below is based on a sample of 10,000 simulated annual data sets. It shows that the current strategy (averaging quarterly measurements for comparison with the 3 μg/L MCL) performs very well! Waters with this pattern and average 1.5 μg/L will almost always be found in compliance. The Type I error rate at 1.5 μg/L is less than 0.05. Waters with this pattern, but averaging 6 μg/L will almost always be found out of compliance. The Type II error rate is less than 0.02.

Performance Diagram



Conclusions

The DQO process proved useful for framing discussions about objectives for compliance monitoring. Applying the process to a past problem allowed us to become comfortable with the process and the concepts behind decision errors, but without the added pressures of real-time decision making. We all feel that we are now in a better position to "hit the ground running," when the next real opportunity arrives.

The neural net model provided a very nice fit with the Missouri occurrence data. In other forms, it also does well with waters that are less variable and have one, rather than two occurrence peaks. These models will be useful for exploring the performance of other monitoring strategies and objectives.

THE CHALLENGES OF IMPLEMETING PROJECT-LEVEL QA PROGRAMS FOR ENVIRONMENTAL PROJECTS IN DEVELOPING COUNTRIES: THE CASE OF NIGERIA

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Abstract

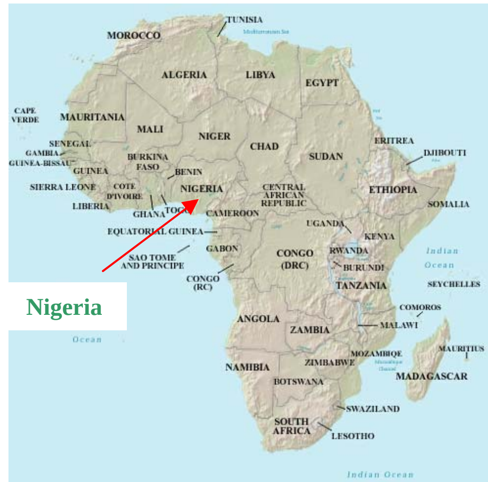
Environmental data is the bedrock of various decisions resulting from several environmental programs. Such data collection efforts may range in scale from simple to extensive depending on the objectives of the program involved. In most cases, significant amount of resources are inherently involved. The collection of environmental data is now fairly standardized with the establishment of systematic procedures like the EPA Quality process for environmental programs. Specifically, the EPA system recommends the Data Quality Objective (DQO) process as a basis for the planning of environmental data collection programs. The DQO is a graded scientific approach to environmental data collection planning. However, systematic approaches to environmental data collection programs like the DQO is yet to enjoy wide acceptance in developing countries like Nigeria. This paper is an expose of the challenges impeding the widespread use of systematic quality assurance practices for environmental projects in Nigeria. It begins with a cogent comparative review of the existing regulatory framework for planning environmental data collection programs in Nigeria and the EPA DQO process. It illustrates the major impediments to the adoption of project-level quality assurance tools (such as the Quality Assurance Project Plan, QAPP) to data collection programs in Nigeria with a case study of an environmental evaluation study in the Nigerian oil and gas industry. It presents key lessons and potentials for the integration of systematic approaches to environmental data collection programs in Nigeria. It concludes with succinct recommendations on how identified gaps could be bridged to ensure the generation of sound environmental data in Nigeria thereby fostering sound sustainable development decision making.

Key Words:
Environmental Data Collection, Data Quality Objective Process, Quality Assurance Project Plan, Environmental Studies, Environmental Decision Making

Introduction

Background

Figure 1: Map of Africa Showing the Location of Nigeria[a]



Nigeria with a total area of 923,800 sq km occupies about 14% of land area in West Africa. The country lies between 4°N and 14°N, and between 3°E and 15°E. It is bordered respectively in the north, east, and west by Niger, the Cameroon, and Benin Republic, while the Gulf of Guinea, an arm of the Atlantic Ocean, forms the southern border (Figure 1).

Serious environmental awareness in Nigeria dates back to the eighties when 400 tons of toxic wastes were imported into the country and clandestinely dumped at a local businessman's backyard in exchange for 100 US dollars a month. Nigeria, lacking any serious environmental regulatory framework at the time of the incident, responded with a plethora of measures. Several environmental regulations were enacted to deal with the situation and prevent a recurrence. Prior to that time, the oil and gas industry was arguably the only sector with enforceable environmental regulation i.e. the Petroleum Act of 1969 which empowered the Minister of Petroleum Resources to make regulations for the prevention of pollution of water courses and the atmosphere. On the international scene, Nigeria became a signatory to several international environmental management instruments.

The public and private sectors responded to the burgeoning environmental regulatory scenario, by deploying several environmental management tools to predict, monitor, audit, evaluate and mitigate the deleterious effects of proposed or existing projects in line with sustainable development practices. Examples of these tools include Environmental Impact Assessment (EIA) Studies, Environmental Audits (EAs), Post-Impact Assessment (PIA) Studies, Environmental Risk Assessment (ERA) Studies, Life Cycle Assessment (LCA) to mention a few. Several of these studies are conducted year in year out. These studies typically involve critical data collection efforts that are the bedrock of decisions concerning environmental quality or other set goals and objectives. The quality of any decision is as good as the quality of data that supports it. Herein lays the essentiality of defensible and representative environmental data.

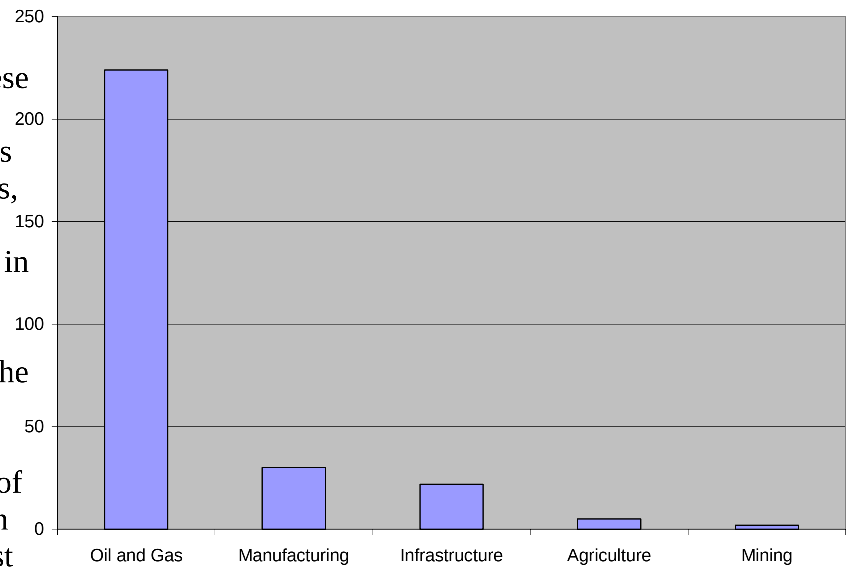
The collection of environmental data is now fairly standardized with the establishment of systematic procedures like the EPA Quality process for environmental programs. Specifically, the EPA system recommends the Data Quality Objective (DQO) process as a basis for the planning of environmental data collection programs. The DQO is a graded scientific approach to environmental data collection planning. However, systematic approaches to environmental data collection programs like the DQO is yet to enjoy wide acceptance in developing countries like Nigeria.

Scope

This paper examines the challenges impeding the widespread use of systematic quality assurance practices for environmental projects in Nigeria. As a starting point, a cogent comparative review of the existing regulatory framework for planning environmental data collection programs in Nigeria and the EPA DQO process is made. It then illustrates the key impediments to the adoption of project-level quality assurance tools (such as the Quality Assurance Project Plan, QAPP) to data collection programs in Nigeria with a case study of an environmental evaluation study in the Nigerian oil and gas industry. It highlights key lessons and potentials for the integration of systematic approaches to environmental data collection programs in Nigeria. It concludes with recommendations on how identified gaps could be bridged to ensure the generation of sound environmental data in Nigeria.

The Regulatory Framework for Planning Environmental Projects in Nigeria

A plethora of regulations govern environmental projects in Nigeria. These regulations include national and state laws as well as international treaties, agreements and conventions. Environmental projects in Nigeria may also be governed by regulations from institutional donors such as the World Bank and the International Finance Corporation (IFC). Over 50 of these regulations are in existence, but by far the most popular are those concerning Environmental Impact Assessment (EIA). Data released by the Federal Ministry of Environment (FMEnv.) indicate that the over 250 EIA reports were approved between 1995 and 2003 (Figure 2). As evident from Figure 2, most of the EIA studies (over 79%) were carried out in the oil and gas sector.



The most relevant EIA regulations are the Environmental Impact Assessment Act of 1992 and the Department of Petroleum Resources (DPR) Environmental Guidelines And Standards for the Petroleum Industry in Nigeria (EGASPIN), 2002. The key provisions of these regulations include the requirement that project proponents conduct an EIA. The EIA process and the content of the EIA reports are also covered. Although, the FMEnv. has released industry-specific EIA guidelines and the EGASPIN contain some provisions on the quality assurance of laboratory and field operations, a systematic framework for quality assurance is completely absent. There is no national regulation dedicated to systematic quality assurance (such as the EPA quality system) of environmental projects in Nigeria. A brief overview of such a system and the attendant benefits are presented in the following section.

The EPA Quality System

Since 1979, the EPA has put in place the EPA Order 5360 mandating the participation of all EPA organizations supporting environmental programs and non-EPA organizations performing work in behalf of EPA through extramural agreements in an Agency-wide Quality System. The Quality System is a management system that provides the necessary elements to plan, implement, document, and assess the effectiveness of QA and QC activities applied to environmental programs conducted by or for EPA. This system embraces many functions including:

- establishing quality management policies and guidelines for the development of organization and project-specific quality plans;
- establishing criteria and guidelines for planning, implementing, documenting, and assessing activities to obtain sufficient and adequate data quality;
- providing an information focal point on QA and QC concepts and practices;
- performing management and technical assessments to ascertain effectiveness of QA and QC implementation; and
- identifying and developing training programs related to QA and QC implementation.

In addition, this Order expands the applicability of QA and QC activities to the design, construction, and operation by EPA organizations of environmental technology such as pollution control and abatement systems; treatment, storage, and disposal systems; and remediation systems. A consistent, Agency-wide Quality System will provide, when implemented, the needed management and technical practices to assure that environmental data used to support Agency decisions are of adequate quality and usability for their intended purpose (EPA, 2000). The elements and tools making up the EPA system are illustrated in Figure 3. The system elements and tools are organized in three groups comprising Policy, Organization/Program and Project. While the policy elements and tools (e.g. Order 5360) constitute the legal basis of the system, the Organization/Program elements and tools apply to the concerned organizations and the Project elements and tools are deployed at the project-level.

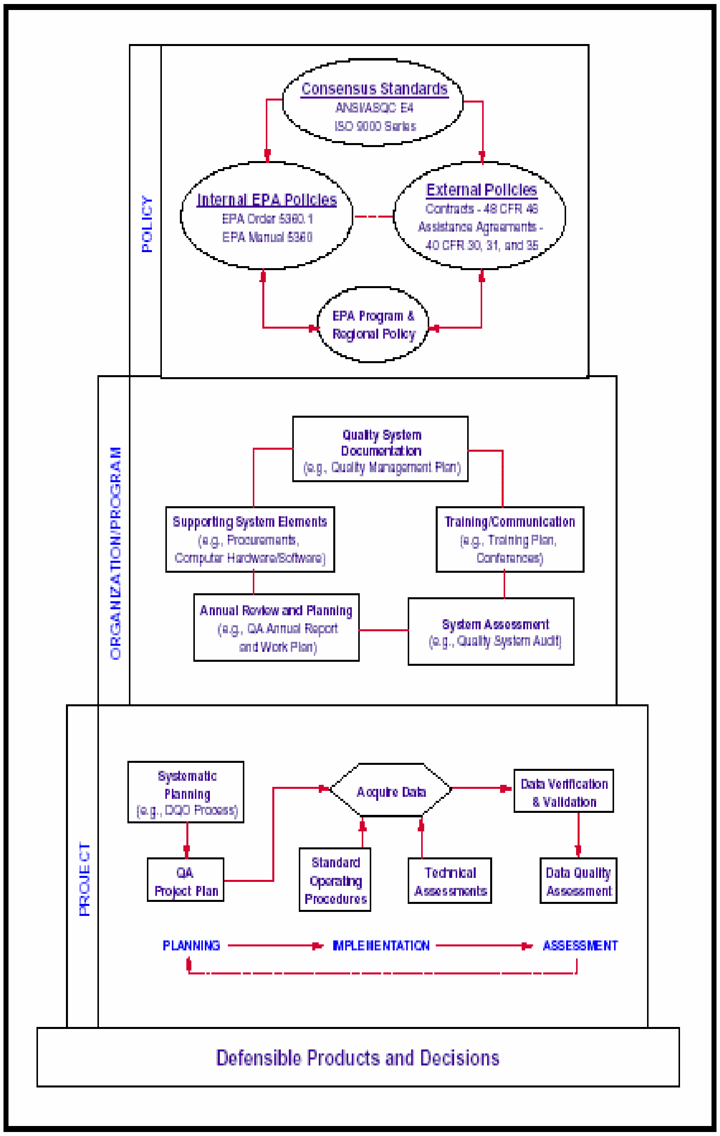
Project Level Systematic Planning Tools

The project-level instruments in the EPA Quality System that supports systematic planning are the Data Quality Objective (DQO) process and the Quality Assurance Project Plan (QAPP).

The DQO Process

The DQO Process is a seven-step planning approach to develop sampling designs for data collection activities that support decision making. This process uses systematic planning and statistical hypothesis testing to differentiate between two or more clearly defined alternatives. A summary of the seven steps is presented in Figure 4. The DQO Process is iterative and allows the planning team to incorporate new information and modify outputs from previous steps as inputs for a subsequent step. Detailed information on the DQO process is provided by the EPA (EPA, 2000a). Upon implementing the DQO Process, environmental programs may be strengthened by:

- focused data requirements and optimized design for data collection,
- use of clearly developed work plans for collecting data in the field,



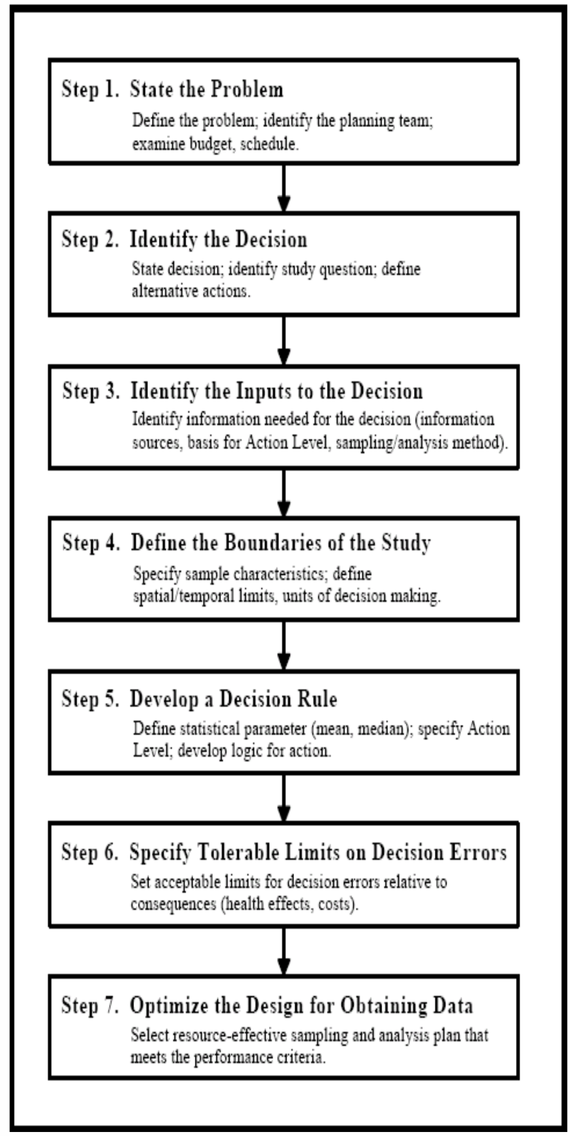


Figure 3: Elements of the EPA Quality System (EPA, 2000)

Figure 4: The DQO Process (EPA, 2000a)

- uniformly documented data collection, evaluation, and use,
- clearly developed analysis plans,
- sound, comprehensive quality assurance project plans, and
- up-front buy-in by stakeholders to the sampling design and data collection process.

Quality Assurance Project Plan (QAPP)

The QAPP is a document describing in comprehensive detail the necessary QA policies and QC technical activities that must be implemented to ensure the results of the work performed will satisfy the stated performance criteria. It is applicable to all projects and tasks involving environmental data operations and covers four (4) central elements including:

- Project Management
- Data generation/Acquisition
- Assessment and Oversight
- Data Validity and Usability

Each of the central issues consists of several sub-elements. Detailed information on the preparation of QAPPs is provided by the EPA (EPA, 1998).

The Challenges of Implementing Project Level QA Programs in Nigeria

Organization and Project-level instruments supporting the systematic planning of environmental programs (DQO and QAPP) lend themselves to use in the absence of a national policy framework such as is the case in Nigeria. Although the absence of a policy framework could encourage a lackadaisical attitude, environmental managers in Nigeria could rely on these instruments in planning environmental programs especially in projects sponsored by multinational companies or institutions that may already be familiar with some of these instruments from their home offices. These tools are largely uncommon and rarely employed by environmental practitioners in Nigeria. The following section presents a case which highlights the impediments to the use of project-level systematic planning of environmental projects in Nigeria.

Case Study: The Environmental Evaluation Study of Abandoned Wells in Nigerian Shallow Waters

Basis. The project proponent (a multinational oil and gas exploration and production company in Nigeria) intended to conduct an Environmental Evaluation Study (EES) of its abandoned wells in shallow offshore fields prior to abandonment and removal of these wells. The EES shall provide scientific evaluations and documentation of the ecological status of the environment. It shall also assess the impact (if any) resulting from past exploration activities in these fields. The EES is in line with the project proponent’s policies on environmental protection and complies with the requirements of the DPR EGASPIN 2002 requirements (Part VIII, section 2.0 and subsection 5.2.6).

Project Scope. The scope of work involves field data collection and laboratory analyses to determine existing impacts/pollution (if any) arising from past exploratory activities in the abandoned well environment and report writing documenting findings. The environmental themes covered included ambient air, surface water and sediments. Specific parameters relating to oil and gas exploration and production operations (such as TPH, Hydrocarbon degraders, etc) were penciled for analysis. Previous environmental studies in the area were to be copiously used as baselines amongst others as part of the decision making process.

The Project Scoping Process: The project proponent prepared the scope and forwarded it to the DPR for approval. The DPR approved the scope which makes it the benchmark for the report approval.

The Project Award Process: The project was awarded after some accredited environmental consultants were short listed and invited to competitively bid for the project by the project proponent. In line with statutory requirements, the project proponent awarded the project to the lowest bidder with an acceptable technical approach.

Project Planning Process. The consultant developed a workplan and forwarded it to the project proponent who approves it as the basic project planning document. The workplan covered field and laboratory quality assurance and control elements.

Project Execution. Fieldwork and laboratory analyses activities were carried out. Reports were prepared by the consultant and submitted to the project proponent for review and approval. Draft reports were prepared and submitted to the project proponent and DPR for approval. The DPR reviewed the draft report and approved it with recommendations for the execution of an Environmental Management Plan (EMP) to be carried out during the actual abandonment exercise. The project was closed out.

Case Analysis. The project proponent is a multinational company that is familiar with the systematic planning of environmental projects. However, since there is no regulatory basis for such an approach in Nigeria, it was easy for the company to relegate systematic planning issues to the background during the project life cycle.

The scope of work was prepared by the project proponent and approved by the regulators (DPR). The environmental consultant who has had some exposure to systematic planning approaches did not have an opportunity to make any input into the scoping exercise.

The environmental consultant could not integrate appropriate systematic planning approaches to his project execution plan because he had to remain competitive since the project would be awarded to the lowest bidder.

The regulators (DPR) did not consider appropriate systematic planning approaches as worthy of integration into the project scope since there is no regulatory basis for that and they were probably not very familiar with these approaches.

Conclusion and Recommendations

A lot of resources are committed to environmental projects in Nigeria. There is a large body of data in existence but the quality of the data is unknown due to the fact that most of the data were collected without a systematic planning approach. Decision making based on such data is therefore difficult if not outrightly impossible. Project-level systematic approaches are difficult to employ in the absence of a national framework. There is dire need for a policy framework for the systematic planning of environmental projects in Nigeria.

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Steps to Take to Ensure that Data Are Usable, Meaningful, and Legally Defensible

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ABSTRACT

Are you sure your data are usable, meaningful, and legally defensible? Are you willing to take the chance they are not? *Assessment of data quality requires meticulous attention to details as well as an understanding of the "big picture." Well-defined project management procedures, quality assurance and quality control (QA/QC) procedures, and quality assessment checkpoints are instrumental in the execution of a successful field effort and the generation of well-documented, high-quality data to meet project objectives. Unfortunately, the appropriate steps that should be completed to ensure that data are usable, meaningful, and legally defensible are sometimes performed perfunctorily, or sometimes not performed at all.*

Chemical data are used for many purposes, such as delineating the nature and extent of contamination at a site, verifying that a contaminated site is adequately cleaned up, and properly identifying and quantifying potential risks to the environment and/or human health. Data need to be of known quality to be able to support and withstand litigation, toxic tort claims, and a plethora of other end uses. Incorrect decisions and costly repercussions could result from an incomplete or faulty QA/QC process. Therefore, it is critical that appropriate QA/QC procedures and sound science be used to be confident in the overall quality (and limitations) of the data being used.

This paper presents a brief overview of some of the QA/QC procedures that should be completed to define and understand the overall quality of analytical data. Case examples are presented to show what errors can occur when appropriate QA/QC procedures are not followed. The examples are intended to illustrate the consequences of using incorrect or poor quality data, which can result in incorrect interpretations of the data, improper decisions, increased project costs, and many other consequences.

INTRODUCTION

Well-defined project management procedures, QA/QC procedures, and quality assessment checkpoints are instrumental in the execution of a successful field effort and the generation of well-documented, high-quality data. Appropriate decisions (or end uses of the data) can only be made by knowing, in part, the following: 1) that the purpose of the project was clearly stated; 2) that proper data quality objectives (DQOs) were established; 3) that proper types and numbers of samples were collected, that sampling locations were appropriate, and that correct sample collection techniques were used; 4) that appropriate analytical methods were used and analyses were completed properly; 5) that data verification and data validation were properly completed (including that the overall quality of the data and any limitations were identified); 6) that the data sets were subjected to a proper data quality assessment (DQA) and usability evaluation; and, 7) that a "reality check" was done to confirm the findings and that any decision(s) made were correct.

QA/QC PROCEDURES – A GENERAL OVERVIEW

It is critical that appropriate and well-defined QA/QC procedures are established at the beginning of any investigation and then appropriately used to assess the overall quality of data. In part, this is accomplished by proper project planning, establishing logical DQOs, preparing complete project documents (e.g., work plan, field sampling plan, and quality assurance project plan [QAPP]), completing data verification, completing data validation, and completing DQA and usability evaluations.

Proper planning is essential at the start of any project. The objectives of the work to be completed must be fully understood. Any existing data should be reviewed to assess their quality and usefulness, and to identify any data gaps that will need to be filled to meet the project objectives. Logical DQOs can then be established. Next, pertinent project documents (e.g., a work plan, a field sampling plan, and a QAPP) will need to be prepared. Appropriate field sampling design and sampling techniques must be determined. Analytical methods must be selected that are appropriate and that will meet required reporting limits and accuracy levels. In addition, a well-qualified analytical laboratory must be selected to complete the testing; an audit of the laboratory may be required.

Completing data verification, validation, and DQA and usability assessments are the aspects of the QA/QC process that are necessary in order to establish the overall quality of data, identify limitations, and assure that the data can reliably be used as intended. The purpose of data verification is, in part, to ensure that all procedures specified in the project planning documents (e.g., work plan, field sampling plan, and/or QAPP) were followed, that correct protocols were used in the field to collect samples and that the samples were correctly analyzed at the laboratory, to verify the completeness of the data set and supporting documentation, and to verify the accuracy of the database. The purpose of data validation is to evaluate the technical quality of the verified data with respect to the project DQOs and method quality objectives.

After data have been verified and validated, a DQA and usability evaluation (i.e., a thorough scientific and statistical analysis of the data) should be completed to determine whether the quality of the data used is sufficient to support the intended purposes and to identify and minimize areas of uncertainty involving any decision-making. The general purpose of completing this part of the overall QA/QC process is to evaluate the quality of the data collected during sampling and analysis and to answer such questions as: 1) Can a decision be made with the desired confidence with respect to the quality of the data? and 2) How well has the sampling design met the DQOs?

When appropriate project planning requirements, data verification, data validation, and DQA and usability assessments are not completed or are not correct, the reliability of the data is not known. If there are errors associated with the data, then any uses of the data and decisions made may be incorrect.

CASE EXAMPLES

A few examples of work that has been completed are presented below, illustrating where various steps of the overall QA/QC process were not properly completed, and resulted in significant errors in the use of the data and decisions made.

Case Example No. 1: Assessment of Potential Bunker C Fuel Oil Contamination to Shallow Groundwater *(an example of how an inappropriate analytical method was used and how chromatograms were inaccurately interpreted)*

Purpose of Project: Exponent assessed whether an installed groundwater barrier wall had or had not failed. As part of this work, we evaluated the reliability of petroleum hydrocarbon (PHC) data reported for analyses completed on shallow groundwater samples collected from monitoring wells located in and around a former steam plant (the Site) with known Bunker C fuel oil contamination. This work was initiated because the laboratory was reporting detections of Bunker C fuel oil in the shallow groundwater samples collected downgradient of the barrier wall. The regulatory agency was concerned that contamination was migrating offsite, contaminating shallow groundwater, and migrating toward a nearby river.

Existing Information: PHC analyses were completed on Bunker C fuel oil (a mixture of product and water) collected from an extraction well upgradient of the barrier wall on the Site, and on shallow groundwater samples downgradient of the barrier wall. The groundwater samples were collected on a quarterly basis over several years, from monitoring wells in and around the Site. Analyses were completed for diesel- and residual-range hydrocarbons using gas chromatography/flame ionization detection (GC/FID). Earlier quarterly PHC data were flagged, indicating that an exact match to the Bunker C fuel oil standard used by the laboratory was not apparent and that the PHC might have been weathered. Data reported for more current sampling events were not flagged, implying that Bunker C fuel oil was present and was not weathered.

Issue(s) Identified: Exponent's review and evaluation indicated that all previously reported PHC data were suspect because of poor chromatography, lack of cleanup of the sample extracts, inadvertent quantification of responses of chromatographic peaks not attributed to nor within the elution range of Bunker C fuel oil (i.e., late-eluting paraffin compounds typical of waxes), and inconsistent flagging of the analytical results.

Solution(s) to the Problem: Detailed chemical fingerprinting analyses were completed to determine the chemical composition of the Bunker C fuel from the Site, the chemical composition of any PHC in the shallow groundwater samples, and to determine if there were any possible similarities between PHCs among any of the samples. This was accomplished by having analyses completed for saturated hydrocarbons (i.e., alkanes) using GC/FID, polycyclic aromatic hydrocarbons (PAHs) using gas chromatography/mass spectrometry (GC/MS), and for chemical biomarkers (i.e., steranes and triterpanes) using GC/MS.

The data reported for the saturated hydrocarbon, PAHs, and chemical biomarker analyses were validated and evaluated by Exponent. Data validation was completed to verify that the laboratory QA/QC procedures were documented and followed, and that the quality of the data was sufficient to support the use of the data for their intended purposes. As part of the validation of the data, a thorough review of all instrument printouts (e.g., quantification reports, chromatograms, mass spectra, and histogram plots) was completed. Data evaluation involved direct comparisons of the analyte concentrations, comparisons of the hydrocarbon analyte distributions (i.e., saturated hydrocarbon, PAHs, and chemical biomarkers) and evaluations of the PHC fingerprint by reviewing the sample histograms, chromatograms, and other instrument printouts generated by the laboratory.

Results/Conclusions: An evaluation of the PHC data from the product sample indicated that it was consistent with a slightly weathered heavy fuel oil (i.e., No. 6 fuel oil or possibly No. 4 fuel oil). In contrast, distributions of the hydrocarbons (i.e., the saturated hydrocarbons, PAHs, and chemical biomarkers) in all but one of the shallow groundwater samples clearly showed that the source(s) of the trace hydrocarbons present was not related to the fuel oil that was characteristic of the PHC from the Site.

The key conclusion was that the weathered Bunker C fuel oil found in the extraction well, which was characteristic of Site contamination, was not migrating offsite and was not the source of the trace or low levels of PHCs found in the groundwater samples collected for this study. Based on this information, and other information, it was proven the barrier wall had not failed, the shallow groundwater was not being impacted by site contamination, and there was not a threat to the nearby river. This example illustrates that appropriate analytical methods are necessary to meet project objectives.

Case Example No. 2: Assessment of Transport and Fate of Dioxins and Furans at a Former Wood Treating Sit*e (an example of how not completing verification of the database can result in major errors in data interpretation)*

Purpose of Project: Exponent evaluated the probability of historical and ongoing migration of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDD/Fs) from a former wood-treating site (the Site) into the adjacent river and subsequent accumulation in river sediments. This work was completed because existing interpretation of the data indicated there was likely migration of PCDD/Fs and accumulation in river sediments, thus posing potential risks to the environment.

Existing Information: Several years of PCDD/F data for analyses completed on samples of perched groundwater, surface water, onsite soil, and sediment (from a slough) were summarized in several remedial investigation reports generated by several consultants. Risk assessment evaluations based on the reported PCDD/F data were also completed. Exponent obtained and reviewed previously reported Site data and all associated laboratory data reports and instrument printouts. We identified what appeared to be anomalous PCDD/F detections in samples from the perched groundwater. We evaluated geochemical factors for transport and fate, potential transport pathways, and completed a "worst-case" estimate of potential accumulation of PCDD/Fs in river sediments.

Issue(s) Identified: It was determined that the laboratory data for analyses completed on the perched groundwater were correct, but there were significant unit conversion and transcription errors in transferring the laboratory results to the supplemental remedial investigation report generated by another consultant. Specifically, the pg/L units (reported by the laboratory) were incorrectly converted to 1×10^{-6} mg/L rather than 1×10^{-9} mg/L. Many of the PCDD/F results reported as undetected (*U*) by the laboratory were reported as detected values in the database. The results of the PCDD/F analyses completed on sediments and onsite soils were found to be correct. There were no unit conversion errors identified, but there were transcription errors in the remedial investigation report (i.e., misplaced decimal points, results labeled undetected (*U*) by the laboratory were reported as detected results (and vice versa), sample numbers were switched, and there was inconsistent use of either the I-TEFs or the WHO TEFs).

Solution(s) to the Problem: The database was updated to correctly reflect the validated data reported by the laboratory. Once correct data were input, the conclusions derived by the other consultants were reassessed and a simplistic calculation was conducted to estimate the worst-case concentration of PCDD/Fs in river sediments.

Results/Conclusions: Using the corrected PCDD/F results, it was shown that there were either no detections or very low background detections.

The key conclusions were that once correct data sets were used, detectable concentrations of PCDD/Fs were within background levels, migration of PCDD/Fs to the river was unlikely, there was no likely risk to receptors, and in-river sediment sampling was not needed. This example illustrates that the verification process must be completed.

Case Example No. 3: Assessment of PCB Contamination from Soil to Groundwater
(an example of how incorrect conclusions were drawn using poor quality data and unsubstantiated rationales)

Purpose of Project: Exponent reviewed, evaluated, and responded to findings stated in an expert report regarding, in part, the reliability of reported PCB contamination of surface soil and subsequent contamination of groundwater.

Existing Information: Data collected from various past and current site investigations, expert reports prepared by consultants, and summaries of analytical data were reviewed. To facilitate the review of the PCB data, all original laboratory data reports and chromatograms were obtained. Aroclor® 1260 was reported as detected in soil samples and Aroclor® 1242 was reported as detected in a groundwater sample. Consultants stated that Aroclor® 1242 in the groundwater could have resulted from contaminated soil introduced during well construction, or perhaps from degradation of the Aroclor® 1260.

Issue(s) Identified: Based on the review of the original laboratory chromatograms, it was evident that the Aroclor® 1260 reported by the laboratory should have been considered as tentatively identified and possibly reported as a false positive. There was no definitive pattern recognition of Aroclor® 1260 in the soil samples. However, evaluation of the chromatograms clearly showed the presence of multiple non-PCB peaks that were determined to be from the presence of chlordane (an organochlorine pesticide), which was confirmed with the analytical laboratory. It was evident that relatively unweathered Aroclor® 1242 (or possibly Aroclor® 1016) was present in the groundwater sample collected.

The argument that the relatively unweathered Aroclor® 1242 found in the groundwater resulted either from Aroclor® 1242 that was once present in the soil or from weathering of Aroclor® 1260 migrating from soil to groundwater was preposterous. It simply is not possible to "create" Aroclor® 1242 by the dechlorination (or degradation) of Aroclor® 1260 via biological, chemical, or physical degradation processes. Further, had the Aroclor® 1242 been in the soil, a chromatographic "fingerprint" most likely would have been evident.

Solution(s) to the Problem: It was demonstrated that chlordane was the primary chemical of concern in the soil and that the presence of Aroclor® 1242 in groundwater could not be attributable to the tentative presence of Aroclor® 1260 (and chlordane) in the soil. A rebuttal to the expert report was submitted citing the results of our review.

Results/Conclusions: It was determined that many interpretations and statements made in the expert report concerning PCB identification, source materials, and transport and fate, were factually inaccurate. Many of the conclusions drawn by consultants were not based on complete, accurate, and valid scientific data or appropropriate data interpretation. PCB contamination from other sources was not adequately addressed in the expert report. Overall, the conclusions drawn for the existing data were unfounded and there was not sufficient evidence presented to substantiate the claims made in the expert report. In the end, the finding in the expert report was not legally defensible and the case was settled out of court and favorably for our client.

CONCLUSION

If the overall quality of data is not well defined, or not known, and/or data limitations are not identified, then all subsequent end uses of and decisions made using those data can be incorrect. Clients, competitors, and regulators will always remember your mistakes. Therefore, it is important to remember to do the following:

- Always ask yourself if these data make sense – do a "reality check"
- Critically evaluate (and re-evaluate) your data
- Make sure that all interpretations of analytical data are completed by an experienced professional

- Be sure to establish and follow appropriate and well defined QA/QC and QMS procedures
- Avoid embarrassing moments—be sure the data and the conclusions drawn are scientifically valid and are legally defensible.

“**Quality assurance is the thread that weaves together the fabric of diverse disciplines.”**

A quote (with permission) by George M. Brilis, QA Manager,
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