The systematic Measurement Planning Process (a.k.a the Measurement Core Loop)

This file will walk you through the features and the functions of the measurement core loop

Introduced by **Revital Katznelson**, State Water Resources Control Board, June 2006

Measurement Systems are…

… Devices and/or procedures used for quantitation of environmental characteristics, including instruments used for field measurements and sampling & analysis processes.

One Measurement System may use **many** of these steps:
Sample collection – compositing – aliquoting – preservation – neutralization –
reaction w reagents – quantitation of product – extraction – distillation – concentration of extract – chromatography to clean the extract – separation of substances – detection of peaks – quantitation of peaks – identification of peaks – flame atomization – quantitation of specific signal - - - etc.

The systematic 5-step Measurement planning process:

(1) Formulate a specific study question,
(2) Select characteristic to measure for generation of data that will answer your question,
(3) Select quality objectives that are adequate to answer the question,
(4) Select Measurement Systems that have adequate performance to achieve the desired MQOs, and
(5) Define requirements for the types and frequency of quality checks, and acceptance criteria for their outcomes.

These steps are the Measurement Core Loop of a Monitoring Plan. They are applied to each study question, and are repeated for each new study question.

Project Background, Problem Definition, Project Objectives

1

Study Question

2

Parameter Package

WQ Character-istics

Analyte – Medium Combos

3

Quality Objectives for these indicators:

Accuracy (inc. Bias, Recovery)

Precision

Target Reporting Limit and Resolution

Representative-ness

Comparability

4

Measurement Systems

Specifications (for Analyte-Medium Combos)

Performance Criteria

Special Methods requirements

5

Program Requirements

Types and Frequency of Quality Checks

Acceptance Criteria for Quality Checks Outcomes

The rest of the Monitoring Plan and the QAPP (Stations, timing, personnel, roles, training, audits, etc. – long list)

First view: The Measurement Core Loop for one Line of Inquiry (simple question)

See definitions in the next slides

Notes on the First View

The Study Question is formulated by the user. All consecutive steps are designed to collect monitoring Results that will answer that question (A Monitoring Result is the outcome of a field measurement or a lab analysis).
Example: Are the failing septic systems in the town of Pensia contributing to E. coli counts in Sycamore Creek?

Parameter Package: list of WQ characteristics to be measured in the field, combined with the lab analytical suite. This is also selected by the user. Example: Specific conductivity and ammonia in field, E. coli and Chloride in lab.

1

Study Question

2

Parameter Package

WQ Character-istics

Analyte – Medium Combos

Notes on the First View (continued)

3

Measurement Quality Objectives (MQOs) for the Data Quality Indicators called 'accuracy' and 'precision' are the numerical values (and units) we desire to have for the data, so they can be used to answer the question. We also state the desired target reporting limits (TRLs) and resolution as numbers. Quality Objectives for representativeness and comparability are usually narrative statements.

Example for Specific Conductivity: for the data quality indicator called 'accuracy', the Project's desired outcome is no more than +/-5% of the Standard solution. QO example for chloride: spike recovery should be between 85% and 115% of nominal spike concentration.

Quality Objectives for these indicators:

- Accuracy (inc. Bias, Recovery)
- Precision
- Target Reporting Limit and Resolution
- Representative-ness
- Comparability

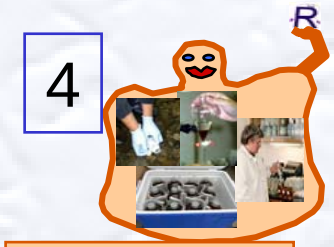
Notes on the First View (continued)

Measurement systems (MeaSys's) are chosen for each analyte/medium combination to deliver the desired quality (i.e., the Quality Objectives), and they have a set of given specifications for each combination. Users do not choose the specifications; they are properties of the MeaSys. EPA and APHA have generic specifications recommended for common analyte/medium combinations, based on the analyte's properties, but these must be adapted to your chosen MeaSys.

Each measurement system has its own capabilities and limitations and can thus operate within a given set of Performance Criteria, a.k.a. Control Limits. MeaSys Performance Criteria are sometimes given as Laboratory Control Charts, or as Pre-established criteria (e.g., from an EPA method).

Users do not choose the Performance Criteria; they are properties of the MeaSys. However users need to check the actual performance each time to make sure the MeaSys operates within its Criteria.

Examples: the ECTestr low+ Pocket Meter can achieve +/-4% accuracy and will be used for this Project; EPA method xxxx for chloride has a performance criterion of 90%-110% Recovery at Sunny Side Lab and will be used for this Project; Samples for chloride analysis will be collected in 200 mL plastic bottles per EPA method xxxx.



Measurement Systems

Specifications (for Analyte-Medium Combos)

Performance Criteria

Special Methods requirements

Notes on the First View (continued)

More to say about Measurement Systems…

Some Measurement systems have 'published' performance criteria but labs often get better performance (the published criteria are often the worst case so all labs will be able to deliver at least that quality).

Measurement systems can also be modified. What happens when you talk to a lab and they tell you that they can tweak the method to improve performance? Examples: attain a lower detection limits by extracting a bigger volume of sample; add another cleaning step to an extract to remove matrix interference.

When the lab modifies an SOP they are actually creating a new Measurement system, with new Performance Criteria and new specifications. Example: the detection limit is different, and the specification for sample volume is different.

EPA has a set of rules as to what constitutes a modification that is notable enough to justify a change in the Method # or an addition to the Method #.

Notes on the First View (continued)

Quality Checks include blanks, duplicates, spikes, positive/negative controls, accuracy/calibration checks, and other types of tests conducted to check and document the performance of each MeaSys. They have numerical or binary outcomes.

A monitoring Program (e.g., SWAMP) develops a list of Requirements regarding the types and frequency of Quality Checks. These are NOT Quality Objectives. The list may or may not incorporate special quality check requirements that are also required by certain MeaSys's. SWAMP Requirements may be 'relaxed' for some Projects under justified circumstances.

Examples: Operators will collect a field duplicates with every 10th sample, lab will run MS/MSD with each analytical batch.

Outcomes of Quality Checks are compared to MeaSys Performance Criteria to determine if data are valid. They can also be compared to the Program's Acceptance Criteria to determine data comparability with that Program.

Program Requirements

Types and Frequency of Quality Checks

Acceptance Criteria for Quality Checks Outcomes

Special Methods requirements

Notes on the First View (PBMS)

Use of a Performance Based Measurement System (PBMS) is another way of meeting the Project's Measurement Quality Objectives (MQOs) if the user cannot find an established method, with known Performance Criteria, to fit their needs. Application of PBMS involves the use of special protocols to test the method at the appropriate rigor, and to establish new Performance Criteria for, e.g., recovery, precision, and detection limit.

A monitoring Program (e.g., SWAMP) can develop a list of Acceptance Criteria for PBMS 'output' for, e.g., recovery, precision, and detection limit. PBMS's that meet these Acceptance Criteria, or do even better, can be used to produce data that will be comparable to other data generated by the Program.

Summary: who does what

What we select: 1
- Study Question
- Parameter Package
- Quality Objectives
- Measurement systems

What the Measurement System specifies we use or do: 2
- Decontamination
- Containers
- Sample volume
- Preservatives
- Holding times
- Calibration
- Etc.

What the Measurement System can 'deliver': 3
- Resolution
- Detection Limits
- Recovery (e.g., of spikes & surrogates)
- Precision
- Etc.

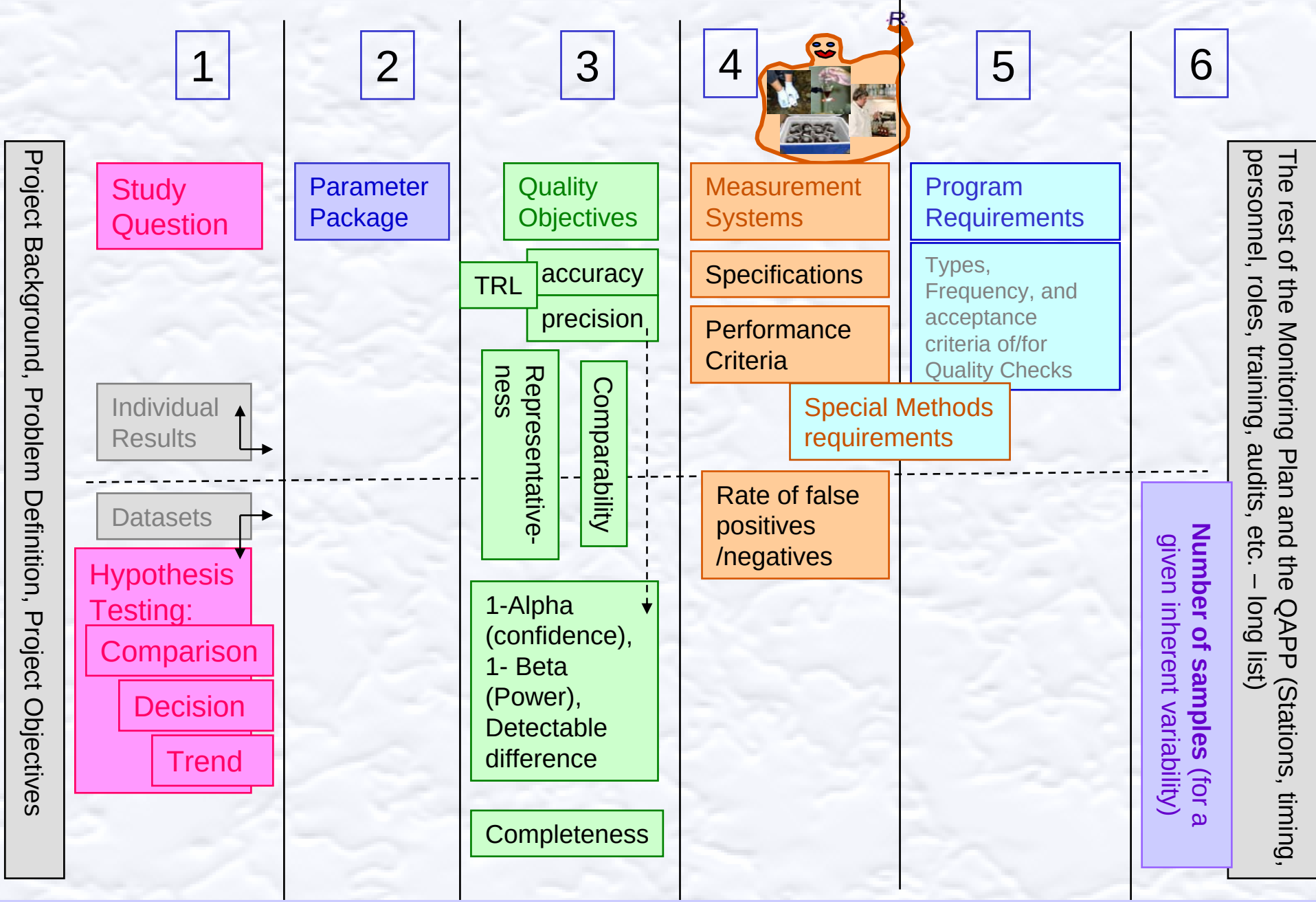
What SWAMP requires at prescribed frequency: 4
- Blanks
- Duplicates
- Spikes
- Positive/negative Controls
- Reference Toxicant tests
- Etc.

What we check: 5
- Agreement between repeated measurements (via duplicates)
- Instrument movement (drift) away from the calibrated state (via accuracy checks)
- % Recovery (of spikes)
- Analyte concentrations in blanks
- Etc.

(i.e. how the Measurement System actually Performs)

So far we talked about individual Results, i.e., outcomes of a field measurement or a lab analysis (they can be generated and validated in batches, but each Result still represent an individual data point with its accuracy and precision)

Now we need to expand the Core Loop picture to include groups of Results, or Datasets.



Second view: Linking hypotheses or decisions, related to an entire **dataset,** to the measurement Core Loop for one Line of Inquiry.

Dataset Examples

Project Objective example: determine the effectiveness of creek fencing MM in reducing nutrient load

1. **Null Hypothesis example: Creek fencing for cattle exclusion did not reduce nutrient input into Pelican Creek as determined two years after construction**

1. **Decision example: can dredge spoils from Sunny Cove be disposed at the deep-ocean site? (alternative: class 3 landfill)**

1. **Trend example: diazinon concentrations in urban runoff samples have decreased significantly during the period 1995 – 2004 (plot: diazinon concentrations as a function of time)**

2. and 4. Have already been discussed Re: Individual Results (inc. lab batches)

3. **Data quality indicators may have different names for each type of dataset use, but they are all derivatives of Confidence level (1-alpha), Power (1-beta), and minimum detectable difference (MDD). Data Quality objectives (I.e, desired outcome for each indicator) will vary, case by case, based on what we can tolerate. Completeness also relates to a dataset, not individual Result.**

Please refer to further guidance provided with USEPA guidance on the Data Quality Objectives process.