**Monograph 3 Errata – June 2013**
**Amplifications, Clarifications, and Corrections**

SPEE first published Monograph 3 in early 2011 and, after two years of practical user feedback, some amplifications, clarifications, and corrections are now desirable.

## Amplifications

Most of us can recall an ingenious teacher who tricked us into "solving" a mathematical problem by "accidentally" dividing by zero with a resulting impossible answer. The instructor emphasized the need to understand the underlying assumptions and the requirement of upholding the assumptions. The deceptive "dividing by zero problem" illustrated the outcome when the assumptions were violated. The same problem occurs in our evaluation practices, we don't always recognize or understand the assumptions used to create a solution and, if we mistakenly ignore the assumptions, we generate incorrect results.

Monograph 3 presents a practical evaluation method to estimate undeveloped reserves in Resource Plays. To employ these techniques, the evaluator MUST ensure the reservoir is a Resource Play as defined in Chapter 1. The evaluator may be tempted to prematurely declare that a reservoir is a Resource Play. However, the Tier 1 Criteria requires a repeatable EUR distribution and Chapter 2 discusses the minimum sample size (i.e. the number of wells) for the distribution.

Feedback suggests evaluators may be overlooking Table 3.3, "Approximate Producing Well Count at Various Stages of Resource Play Development". In the early phase of field development, insufficient data exists to demonstrate EUR repeatability. Consequently the evaluator cannot determine if the subject reservoir is indeed a Resource Play. Table 3.3 and Table 3.4 offer recommendations of how many PUD locations are justified depending upon field development.

## Clarifications

Graphs 1.1, 1.2, and 1.3 in Chapter 1 are plotted using the equal interval method, a frequently-used graphing technique. The graphs compare well performance over several years. A more rigorous graphing method for small data sets, the mid-point plotting, is discussed in Chapter 2 on page no. 31. For most limited sample distribution graphs, we recommend mid-point plotting.

In Monograph 3, data is plotted as both discrete points and as line connected points. Often data points are "connected" on a graph to improve "readability". Either graphing style is acceptable based upon evaluator discretion. However the connecting line does not infer additional data. For this reason, some evaluators prefer graphs of discrete data points.

Chapter 2 introduces statistics, the study and description of data. The sample Mean is the arithmetic average of the data-set samples. It is the sum of the sample points divided by the number of samples. Similarly, the Population Mean is the average of all the possible population values weighted by their respective likelihoods. The mode, median, mean, and standard deviation of a sample are not necessarily (and rarely, if ever) equal to the mode, median, mean, and standard deviation of the full population

Throughout Monograph 3, we consider wells already drilled to discern properties of undrilled locations. To evaluators, this is a common practice; we study analogous wells to forecast the performance of undrilled wells. In mathematical terms, the analogous wells are a sample, or subset, of the entire population. However, the statistical measurement of a population and a sample are not identical. This includes both central tendency (mean, mode, etc.) and shape (variability, standard deviation, etc.). For evaluators, the prime question is "How representative of the entire population is my sample?" For a Resource Play, error in average EUR decreases as sample size (number of wells) increases. From a practical perspective, the SPEE Evaluation of Resource Plays Committee recommends using well counts from Table 2.1 as the minimum number of wells in a sample.

To prepare Table 2.1, the committee assumed a mean and $P_{10}/P_{90}$ ratio for a log-normal population truncated at $P_2$ and $P_{98}$, then solved for the sample size of randomly selected data yielding a 90 percent confidence interval. In practice, during early development we evaluate a sample or subset of the population (all analogous wells that will be drilled in the field). Therefore we *assume* the mean and shape of the sample will represent the population. As with Table 2.1, many graphs and tables in Monograph 3 are derived for a defined population and applying these to a sample introduces a slight, yet acceptable, error.

To indicate a Resource Play, the evaluator must demonstrate EUR repeatability by comparing different groups of wells. Each group represents a sample of the entire population (all wells that will ever be drilled) and should include enough wells to satisfy the well counts from Table 2.1. For example, if the $P_{10}/P_{90}$ ratio for the field is 4.0, each group of wells (a sample) needs to include at least 60 wells. Group one might be the first 60 wells drilled, group two might be the next 60 wells drilled, and group three might be the last 60 wells drilled. A smaller sample size than suggested in Table 2.1 results in a confidence interval which falls below 90 percent of the target.

In this preceding example, 180 producing wells, or three times the minimum sample size are considered. Once the evaluator determines the reservoir is a Resource Play, all of the wells should be grouped into a single sample for further statistical analysis ($P_{10}/P_{90}$ ratio, Swanson's mean, etc.).

The minimum well count of 60 for a P10/P90 ratio of 4 was selected so that the sample size would meet the SEC's "reliable technology" criteria. In more statistical terminology, a total sample size of 60 is required to assure that we are more than 90% confident that the sample is representative of the population mean. The committee made the

simplifying assumption in all of its aggregation work that the sample (60 wells) mean and variance were equal to the population mean and variance. This was viewed as pragmatic and within the SEC's guidance of reliable technology.

**Corrections** –

Chapter 2 used the lower case Greek letter sigma, "σ", to represent the standard deviation of a sample. Statisticians have standardized on the use of sigma, σ to reflect the population standard deviation and the use of the Roman letter, "s" to represent the standard deviation of a sample. In Monograph 3 we used analogous wells as a sample, or subset, of the entire population. Hence Eq. 2.1 should be:

$$s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x-\bar{x})_i^2$$

Please note, the definition of standard deviation is only provided as an *example* of a statistical measurement and is not used elsewhere in Monograph 3.

Chapter 3 presents the Expanding Concentric Radii (ECR) method to identify the Proved area of a Resource Play. Throughout the discussion, groups of wells are considered "equal" if the mean and $P_{10}/P_{90}$ ratios are within 10 percent of each other. In reality, values which differ by 10 percent are not mathematically equal. Substituting "similar" for "equal" offers a more reasonable discussion.

In Chapter 3, page 52 reads "The following chart, Fig. 3.17, compared the **P^** values for the analogue wells, anchor wells, and three test sets" should read "The following chart, Fig. 3.17, compared the **Pmean** values for the analogue wells, anchor wells, and three test sets"

In Chapter 4, the x-axis on Figure 4.14 should be titled "PUD Well Count".

In Chapter 4, page 69, reads "Both curves show the P^ method has less than five percent error once the well count exceeds **30** wells." should read "Both curves show the P^ methods has less than five percent error once the well count exceeds **35** wells." Later in the same paragraph, "As the graph depicts, the P^ method results in slightly **optimistic** values when the well count is greater than 100 wells." should read "As the graph depicts, the P^ method results in slightly **pessimistic** values when the well count is greater than 100 wells."

In Chapter 4, the x-axis on Figure 4.16 should be titled "Aggregate Factor versus PUD Well Count for Various $P_{10}/P_{90}$ Ratios".

Figure 4.2 has a plotting error. Note that data values with a lower Probability value are occasionally smaller than the value plotted beneath them at a higher probability value. The greater than mid-point method requires the ranking of data from the smallest to the largest value.