EXPERIMENT PROTOCOL: TO HAVE OR NOT TO HAVE
Lesson learned from Green Roof drainage layers lysimeter experiment
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PROJECT: GREEN ROOF RETROFIT
A retrofit green roof, measuring 630 sq. m., was installed atop of the Science Center at Saint Joseph’s University (SJU) in Philadelphia, PA. It was designed and constructed by Roofmeadow Inc. in 2010. It consisted of three-inch deep growing media layer, underlain by two inches of fine aggregate with embedded conduits as a drainage layer. The layers were isolated with geotextile separation fabric. The roof deck was protected with barriers and a water-tight membrane. A wind blanket was installed on the surface to protect soil loss. The green roof performed very well since its construction.

EXPERIMENT: H&H EFFECTS OF DRAINAGE LAYERS
One of the research components of this project was to establish green roof’s hydrologic performance consequent to use of different drainage layers. Four sections of the background roof were replaced with areas with four unique drainage layers. Within each one of these sections, a “boundary-less” weighing lysimeter system, 1.22 m x 1.22 m each, with representative drainage layer, was installed. Each of the systems had identical growth layers. Four Omega LCCD-500 load cells were used for each of the lysimeters.

DATA, ANALYSIS, AND... NO RESULTS!
Due to the magnitude of the “noise”, and its variability between the four sections, no statistically significant conclusions were drawn between the different drainage layers. The data might suggest possible differences in water retention that should be studied further. Although the data does not support the hypothesis, it does not necessarily mean that the hypothesis is wrong. Rather, it shows that the experiment was not conducive to testing the hypothesis.

FLOW/DIAGRAM LEGEND
(1) Hypothesis: having a very specific question simplifies quest for the answer. It might be necessary to refine the hypothesis as experiment design progresses.
(2) Defining measurable: is this the only unknown? Would establishing this parameter “close the loop” in physical process the researcher wants to describe?
(3) Establishing measurable: what is the required precision required to test the hypothesis against previously selected confidence limits? This should be established before equipment selection.
(4) Equipment: apparatus has to be designed to specifically address the questions in hypothesis.
(5) Instrumentation need to be selected to satisfy required data quality.
(6) Resolution: this is a first step in instrument selection. Often confused with measurement’s accuracy.
(7) Repeatability and linearity: these are given by the instrument’s manufacturer. It is a good practice to check those specifications in experiment-specific conditions.
(8) Environmental factors stability: instrument specifications are based on performance in controlled conditions. How would the instruments respond to environmental factors in the experiment?
(9) Measurement range / full scale range: measuring 1 kg change over 10 kg full scale is much easier than 1 kg change in 1000 kg full scale. Counterbalancing is a common mechanical solution.
(10) Signal / noise ratio: the readings reflect actual system behavior or instrument noise. It helps to reduce equipment-related errors.
(11) Prototype: data collection and analyzing prototype data shows whether apparatus and instrumentation are suitable for testing the hypothesis, without committing to multi-year data gathering.
(12) Statistical analysis: the obtained data is expected to be “good”, checking the data against established alarms / flags is desirable.
(13) Run preliminary analysis: unless the data is the same (or similar) analysis per the protocol.
(14) Call the data: test the hypothesis: is, perhaps, an ultimate question in experiment design process. If not, it is not too late to revisit the apparatus, instrumentation, or even the hypothesis.
(15) Collect experiment data: although previous steps are reasonable assurance for getting the data of appropriate quality, don’t forget to periodically inspect the time-series. This would protect against equipment failure that could otherwise go unnoticed.

ACKNOWLEDGEMENTS
Support for this work had been provided by the US Department of Energy. The authors are grateful for this contribution. The authors would also like to thank Ryan S. Lee of Villanova University for his contribution to statistical analysis.

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