Drinking water distribution systems are inherently vulnerable to malicious contaminant events with environmental health concerns such as total trihalomethanes (TTHMs), lead, and chlorine residual. In response to the needs for long-term monitoring, one of the most significant challenges currently facing the water industry is to investigate the sensor placement strategies with modern concepts of and approaches to risk management. This study develops a Rule-based Expert System (RBES) to generate sensor deployment strategies with no computational burden as we oftentimes encountered via large-scale optimization analyses. Three rules were derived to address the efficacy and efficiency characteristics and they include: 1) intensity, 2) accessibility, and 3) complexity rules. To retrieve the information of population exposure, the well-calibrated EPANET model was applied for the purpose of demonstration of vulnerability assessment. Graph theory was applied to retrieve the implication of complexity rule eliminating the need to deal with temporal variability. In case study 1, implementation potential was assessed by using a small-scale drinking water network in rural Kentucky, the United States with the sensitivity analysis. The RBES was also applied to two networks, a small-scale and large-scale network, in "The Battle of the Water Sensor Network" (BWSN) in order to compare its performances with the other models. In case study 2, the RBES has been modified by implementing four objective indexes, the expected time of detection (Z1), the expected population affected prior to detection (Z2), the expected consumption of contaminant water prior to detection, and the detection likelihood (Z4), are being used to evaluate RBES's performance and compare to other models in Network 1 analysis in BWSN. Lastly, the implementation of weighted optimization is applied to the large water distribution analysis in case study 3, Network 2 in BWSN.