Evaluating the Application of the Decision Support Tool

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As the global need for water increases, the dependence on alternative water sources, such as produced water and wastewater, will also grow. However, in order to utilize these new water supplies, the water must first be treated in correspondence with a wide range of standards (depending on its ultimate purpose). The Decision Support Tool (DST) is a VBA-based treatment selection model for many source water types. It is an integrated guidance framework that links water quality to beneficial use. The tool contains a database for feed water quality and target beneficial use water quality requirements. It is capable of suggesting suitable treatment trains and provides a cost-benefit analysis of different beneficial reuse options.

The DST is comprised of four modules that work in tandem to create the most efficient and effective treatment train that meets all constraints. A conceptual framework of the tool can be seen in **Figure 1**. The first module, Water Quality, allows the user to specify what type of water they want to treat, where they want to get it from, and how they want to use it (its beneficial use). The User & Expert Ranking Module involves both economic and technical criteria. This module allows the user to further customize the treatment train by ranking the technical criteria based on what is most important to him/her. The Economic Module includes the known costs involved with each treatment method, such as capital and annual operations and maintenance costs. The last module, Treatment Selection, combines the data from the other three modules and utilizes them to choose the optimal treatment train.

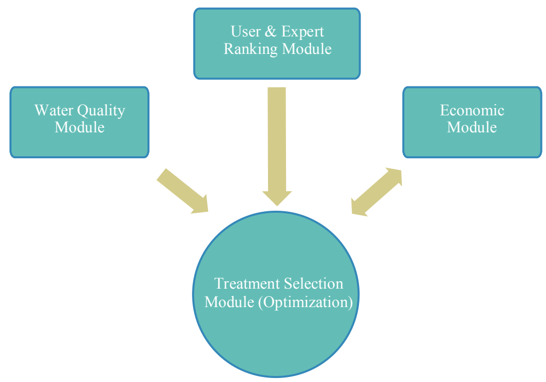

Figure 1: Conceptual structure of the interaction/flow of information between the four modules utilized by the DST for treatment selection

Although the tool itself aims to select the best treatment train with respect to economic and technical criteria while meeting beneficial reuse water quality requirements through the implementation of multi-objective optimization, this project focused mainly on evaluating the tool. This was accomplished by testing different combinations of five parameters – water type, source water (location), flow rate, user technical criteria weighting (user score), and beneficial use of the treated water. More specifically, the five water types were coal bed methane (CBM) produced water, oil and gas produced water, fracking flow back water, geothermal, and municipal wastewater. Various locations were chosen for each type of water, and flow rates of 1 and 2 MGD were implemented. The three user scores tested were the default settings (includes all technical criteria), only considering energy demand and only considering capital and O&M costs. Lastly, the water was treated to be utilized as drinking water, for irrigation, and to be injected into a deep well.

In order to take all criteria into account, the DST must implement multi-objective optimization. Because the DST utilizes both economic and technical objectives, it must simultaneously analyze the conflicting criteria. To consolidate both types of information into one objective function, the technical criteria is converted to numerical values based on user inputs (scores) and pre-rated expert rankings. The user can rate each technical criterium on a scale from 0 to 5, 0 being the least important and 5 being the most important. The expert rankings, however, are on a scale from 1 to 5 and are assigned to each treatment technology with respect to each criterion; higher values signify worse options.

Due to the number of parameters tested, a large amount of data was produced in this project. A sample of that data is shown below in **Table 1**. Throughout most of the

Table 1: Comparison of treatments for varied beneficial uses at a flow rate of 1 MGD

Water Source	Beneficial Use	Treatment Train	Capital Cost ($)	Constituents Requiring Treatment
Oil & Gas Produced Water: Marcellus, PA (TDS = 104,031.5 ppm)	Potable	Air Stripping ➔ Acid Cation IX (H) ➔ BAF/ Media Filter ➔ MVC ➔ Chemical Disinfection ➔ Evaporation Ponds ➔ Brine Disposal	28,950,300	Aluminum, Arsenic (V), Barium, Benzene, Chloride, Chromium-total, Manganese, TDS (calc), Thallium-total, Total Suspended Solids (TSS), BOD5
	Irrigation	Acid Cation IX (H) ➔ Media Filter ➔ MVC ➔ Chemical Disinfection ➔ Evaporation Ponds ➔ Brine Disposal	27,414,200	Barium, Chloride, Chromium-total, Lithium, Manganese, Strontium, TDS (calc), Total Suspended Solids (TSS)

tests, the capital cost of producing water for irrigation was very similar to that of potable water, even though there are much higher requirements for potable water. In some instances involving municipal wastewater, the cost of producing water for irrigation was actually greater than potable water. With this in mind, it was concluded that while the tool provided reasonable treatment trains for most scenarios, real-world applications could introduce additional constraints that need to be accounted for.

In order to address these issues, some future work has been proposed. In terms of improving the tool itself, it would be prudent to add expert ranking data to account for the log removal of pathogens of individual treatment methods so that the cumulative log removal of a treatment train can be calculated and compared to standards. Additional testing is also necessary which would involve choosing multiple beneficial uses and treatment trains. It is believed that these additions and further testing will greatly improve the efficiency and effectiveness of the tool.