An EconomicAnalysis of Alternative Methods to Control Salinity in the Western San Joaquin Valley

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Project 00-004

Executive Summary

Over 50 percent of California's harvest cropland is located in the San Joaquin Valley. Indeed, over a million acres are located yearly to orchards and cotton each. To facilitate the production of these crops, more than four million acres of cropland within the San Joaquin Valley are irrigated. This vast amount of irrigation has lead to some severe drainage problems that pose a serious threat to the future of agriculture in the San Joaquin Valley (Mercer and Morgan, 1991). As illustrated quite well in Dinar and Zilberman's (1991) edited volume on the economics and management of water and drainage in agriculture, there are critical environmental, political, ecological, economical, and social implications surrounding the continued use of the San Joaquin Valley for agriculture, much of which is directly linked to the accumulation of drainage water high in salinity due to the abundance of irrigation. The objective of this research is to evaluate alternative management options for drainage high in salinity due to irrigation in the San Joaquin Valley.

To achieve this objective, a mathematical programming model will be developed that estimates the costs of alternative strategies that have been proposed for decreasing the salinity levels in the Western San Joaquin Valley. Similar to the model developed in Schwabe (1996), and illustrated in an application for controlling nutrient runoff from agricultural and nutrient discharge from industry in Schwabe (1999), this programming model will use a materials and energy balance approach in developing a structural process model to achieve this objective. Such an approach provides both a theoretically consistent and methodologically sound approach to representing production activities, control technologies, and the transport of nutrients, pollutants, and salts, (hereafter referred to as residuals). There are numerous studies that use a similar modeling approach, including Weinberg (1991) and Weinberg, Kling, and Wilen (1996). Indeed, these two studies, while focusing on net returns to land management, addressed the economic concerns surrounding water markets and collected drainage water in the San Joaquin Valley. This present work will be a complement to such studies.

The model will focus on alternative control options available for controlling salinity and various other pollutants in the drainage water in the San Joaquin Valley and the production practices that are responsible for contributing such residuals. Efforts to include the differential impacts of the environment on the control, production, and transport of the residuals that influence the level of drainage water quality in the San Joaquin Valley will be made. Production will be represented as a set of discrete production activities with unit activity vectors. The constraint set includes limits on input availability, output requirements, quality requirements, and continuity conditions. This model is represented mathematically by the following familiar liner programming problem (for cost minimization):

$$\text{Min } c^T x_i \text{ subject to: } Ax \leq b \text{ and } x \geq 0$$

Where x = vector of activity levels (n by 1), c= corresponding price vector for activities x (n by 1), A = structural process matrix for constraint set (n by n), and b = limits on constraint set (n by 1).

The specific approach to assemble the elements in the A matrix will follow the logic developed by Russell (1973). The solution process is comprised of various production and/or residual-influencing blocks, represented by the columns for A. These are subject to constraints such as input availability or continuity conditions, represented by the rows of A. The blocks can be separated into the major residual influencing activities, and include production activities, field transport, control technologies, land transport, steam transport, and residuals discharge. Together, these blocks account for the main influences on the residuals. The nutrient balance approach is achieved through imposing continuity conditions on the rows of the A matrix. Each block treats the output from the previous block as an input. This unit input is subject to each block's residual-influencing process while maintaining continuity (i.e., mass balance). The residual is accounted for explicitly by treatment, some type of recycling, or through discharge into the environment. Other constraints, such as those associated with input availability, output, and environmental quality may also be imposed through the use of additional rows.

Another attribute of the structural process model is its ability to allow alternative activities for residual reduction. Each producer has the option of various production and control strategies. Furthermore, heterogeneous characteristics of the environment across producers are captured in two ways. First, by allowing for differences in the uptake and transport coefficients across agents. Second, by allowing for different unit production coefficients within the production activities vector, or different unit control coefficients within the control strategies vector, given the same technologies.

To obtain the coefficients that will be entered into the process model will require using current and past research on residual transport, control, and production. Furthermore, collaboration with researchers from a variety of disciplines including crop science, hydrology, soil chemistry, microbiology, biological and agricultural science, hydrology, soil chemistry, microbiology, biological and agricultural science, and environmental science among others will be required.