2-7-2019

1995 - Monterey County Water Conservation Alternatives - An Analysis

Monterey County
Water Conservation Alternatives:
An Analysis

Salinas River Basin
Water Resources
Management Plan Study

DRAFT

Submitted to:

Monterey County Water Resource Agency

July 1995

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Monterey County Water Conservation Alternatives: An Analysis

Preface

This research was conducted with funding from the Monterey County Water Resources Agency, under contract with EDAW. Dr. David Sunding and Gary Green, Department of Agricultural and Resource Economics, University of California at Berkeley are the principal authors of Chapter I. Dr. Larry Dale, Agland Investment Services, is the principal author of Chapters II and III. William Scott, Agland Investment Services, is the editor of the paper and the project manager.

All opinions expressed here are solely those of the authors. We wish to thank the staff of the Monterey Country Water Resources Agency, Eric Zigas (EDAW), Dr. David Zilberman (UC Berkeley), the staff of the Monterey County office of the University of California Cooperative Extension, and the numerous growers who participated in our survey.

Monterey County Water Conservation Alternatives: An Analysis

Executive Summary

I. Introduction and Project Goal

The major goal of this study is to estimate the direct and regional economic impacts of different policies aimed at encouraging agricultural water conservation in the Salinas Valley. The study also looks at combinations of conservation measures which could provide a least cost conservation contribution to the seawater intrusion problem. We believe that policymakers should consider adopting a least cost approach when considering the mix of infrastructure projects and urban and rural conservation measures.

Since the infrastructure portion of the BMP had not been fully determined when we were conducting this study, we did not attempt to determine the optimal level of agricultural water conservation, which must be determined in conjunction with urban conservation and infrastructure considerations. Rather, we have provided estimates of the cost of different policies at different levels of conservation.

The economic impact model measures the impact of the following policies designed to encourage agricultural water conservation:

1) Region-Specific Pumping Charge (Acre Foot)
2) Region-Specific Land Use Charge for Groundwater Pumping (Acre)
3) Uniform Pumping Charge (Acre Foot)
4) Uniform Land Use Charge for Groundwater Pumping (Acre)
5) Tradable Groundwater Withdrawal Permits (Acre Foot)
6) Region-Specific Upper Pumping Limit (Acre Foot per Acre)
7) Uniform Upper Pumping Limit (Acre Foot per Acre)
8) Tiered Groundwater Pricing (Acre Foot)
9) Irrigation Technology Improvements

All policies but three change the price of water; the pumping limits and irrigation technology policies do not affect the price of water directly. The direct impact model measures lost net farm revenues from each of these policies as well as the actual charges necessary to achieve conservation goals (See Table 1 in the study).

Specific conservation measures include fallowing, investment in low-volume irrigation technology, and changes in water management practices such as irrigation scheduling and irrigation consulting (i.e. the California Department of Water Resources' Mobile Lab facility).

II. Methodology

To measure the direct cost of different conservation policies, we built a computer model which measures economic impact at the farm level. Using farm-level production costs provided by wide range of farmers who participated in our survey, we built a model which included 7 major crops in Salinas Valley, broken down by four subareas and also by season (See Appendix 2 in the study for detail). Our model's assumptions were verified several times by the farmers in the survey to ensure that the numbers used in the model were as accurate as possible.

In addition, the model incorporates hydrologic data from the IGSM model of Montgomery Watson. Statistical analysis of this data reflects Montgomery Watson's conclusion that groundwater pumping in the north valley has over 13 times the effect on seawater intrusion as does pumping in the south valley. This hydrologic data is combined with the economic data to calculate the costs of different water conservation solutions.

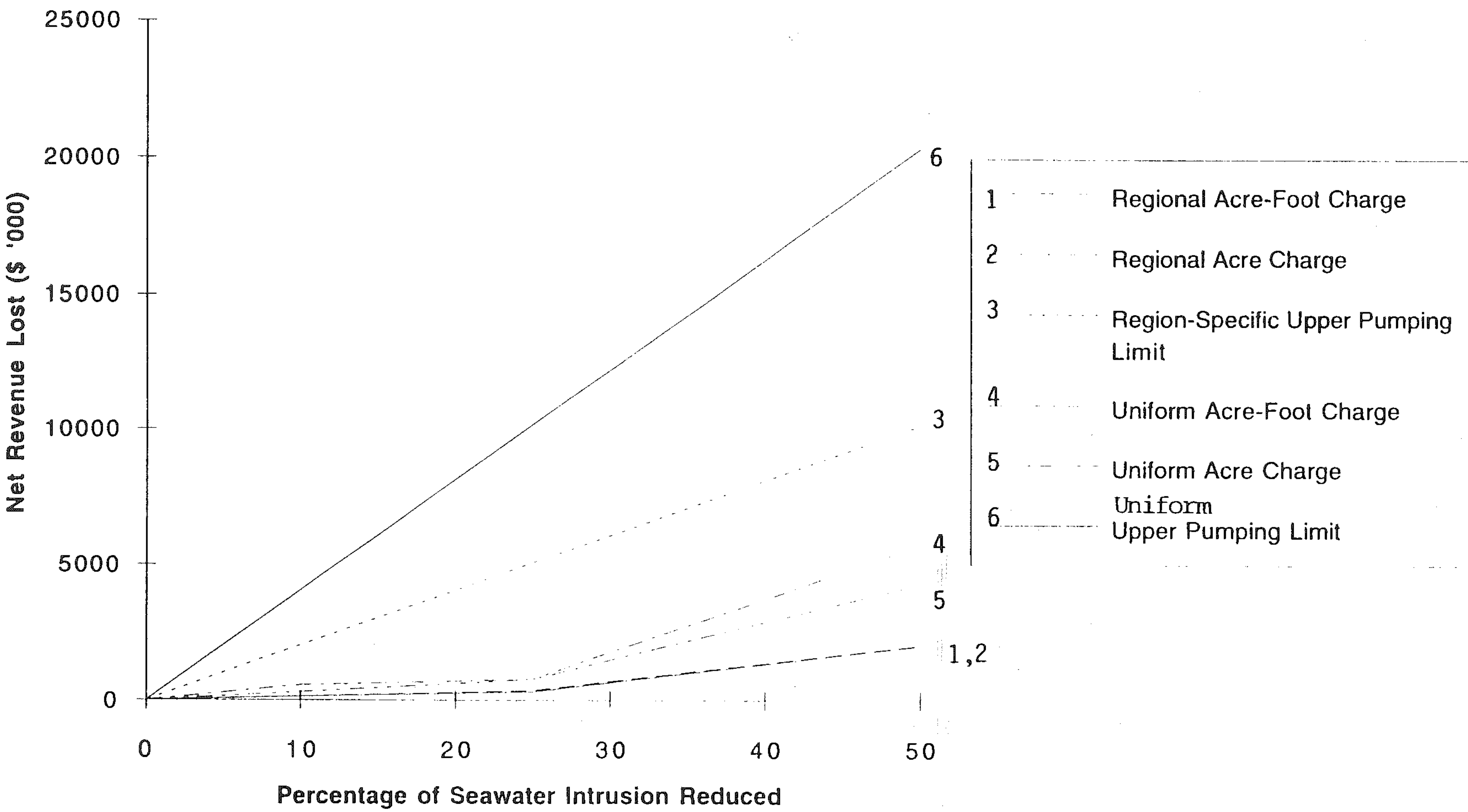
To measure the county-wide or regional costs, we used a standard input/output model -- IMPLAN -- to calculate the indirect and induced impacts of different policies. IMPLAN uses the numbers generated by the farm level model, expressed as total sales of agricultural commodities, and then uses multipliers to estimate the potential impact of policies on the overall economy, including revenues lost to the county as a whole and job losses (Tables 3 and 4 in the study, respectively). These regional estimates should be considered worst case, since IMPLAN, while cost-effective and a standard methodology used in the economics profession, is rather rigid in the way it arrives at these figures.

III. Direct Costs

The economic impact model identifies the farming activities in the Valley that contribute the most to seawater intrusion while generating the least profit; these are the activities that should be curtailed first to meet the environmental objective of stabilizing seawater intrusion. Generally, farming closer to the coast is more profitable than farming inland, a result of favorable climatic conditions near the ocean that permit the production of higher-value crops. However, farming near the coast also has the greatest marginal impact on seawater intrusion. There is, thus, a natural tradeoff between economic productivity and environmental damage to the aquifer that drives the impact model.

The graph on the next page shows for the major policies considered the estimated cost of the implementing these policies. In general, the policies the least costly to the economy are the region-specific water charges (per crop acre or per acre foot charged at different rates to different regions - See Table 2 in the study). The most costly policies are upper pumping limits - either region-specific or uniform. Uniform water charges, made at the same rate throughout the Valley on either on a per crop acre or a per acre foot basis, were in the middle of the cost range.

Reduction in Net Revenue and Seawater Intrusion



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The detailed numbers for the various policies are shown in the full text (Table 1), as well as estimates of the necessary water charges (Table 2). In general, our analysis suggests that agricultural water conservation can be a viable component of an overall program to stabilize seawater intrusion in Monterey County. For example, we estimate that water conservation alone can reduce 25 percent of seawater intrusion at a direct cost to Salinas Valley farmers sector of $313,000 per year under either of the region-specific charges.

Above all, this analysis demonstrates the importance of a regional approach as opposed to a uniform policy that treats all growers equally, regardless of their contribution to the seawater intrusion problem. In addition, season-specific charges may also be able to encourage farmers to not grow crops which are marginally profitable but yet consume water.

The results generated by the rationing model can be used to determine how agricultural water conservation can contribute to a multifaceted program that uses many tools to stabilize seawater intrusion. For example, there are a number of physical projects that can slow or stop seawater intrusion, and agricultural water conservation can complement these other approaches.

IV. Regional Costs

Implementation of ground water conservation strategies in the Salinas Valley would result in somewhat reduced crop acreage and crop production in the County. The purpose of this section of the report is to estimate the subsequent regional (i.e., county-wide) economic impacts brought about by the initial or *direct effect*.

Regional economic impacts occur because of the spending patterns of inter-sectoral transactions within the county economy. In the course of vegetable or fruit production, for instance, goods and services are purchased from other sectors within the county economy. Likewise, fruit and vegetable commodities are sold to the food processing sector and for household consumption, government purchases, and exports outside of the county. Hence, changes in agricultural production have impacts on other sectors of the economy.

The conservation policy options for stabilizing seawater intrusion into the Salinas Valley aquifer would result in a reduction in crop production and a commensurate impact on the regional economy. For example (See Table 3 in the study), a 10 percent reduction of seawater intrusion by means of the conservation policy options can result in a reduction in vegetable and fruit sales of between $27.7 million for the most efficient policy and $104.5 million for the least efficient policy. This loss -- constituting a 1 percent to 5 percent reduction from 1992 crop sales -- would be brought about by a roughly 2 percent to 4 percent reduction of crop acres in the county. The total county-wide regional impact (direct, indirect, and inducted impact on employment) for this example would be between $51.9 million for the most efficient policy and $195.5 million for the least efficient policy. This would account for county-wide losses in employment of an estimated 734 jobs (See Table 4 in the study) for the most efficient policy and up to 2,763 jobs for the least efficient policy. This represents between 1-4 percent of the jobs in the agricultural sector. While the regional costs of conservation are not insignificant, these costs should be compared to the cost of alternative methods of stabilizing seawater intrusion to determine the relative merits of each method.

A policy of encouraging irrigation technology and management improvements would result in a minimal reduction in crop production and is therefore not estimated to have a substantial impact upon the regional economy. In general, the regional impacts of this option would vary depending upon the source of funds used to pay for the technology, and the impact of the technology upon crop yield. If the irrigation technology were purchased by farmers from the farm equipment sector, it would represent a drop in farm sector income and a rise in farm equipment sector income, with largely offsetting effects. Increases in yield associated with irrigation technology would cause an increase in farm sales, with generally positive impacts upon farm income and the regional economy.

V. Recommendations

We would summarize the results of our study into the following three recommendations:

1) Agricultural conservation policies should be designed in a way that imposes the lowest possible direct cost to farmers and the lowest possible indirect cost to the regional economy. **This goal is best accomplished with region-specific and season-specific land use or pumping charges.** Such charges can be tailored to influence cropping patterns during seasons when the costs of fallowing are lowest, and in regions where the benefits of fallowing are greatest.

2) We further recommend that proceeds from land use or pumping charges be used to encourage improved irrigation management and technology adoption. The regional and indirect costs of this policy are much lower, because agricultural land is kept in production. When the water quality benefits of improved irrigation to the region are included, the regional impacts of this policy may well be positive. We suggest that a program of modest charges to encourage crop fallowing, combined with subsidies to encourage better irrigation management, is one of the more promising options available to the County and should be given further consideration.

3) Finally, we recommend that the other components of the BMP project be evaluated in a similar way in order to choose the least cost mix of agricultural and non-agricultural policies to stabilize seawater intrusion. This might include studies of a) the cost of smaller BMP engineering alternatives; b) the cost of urban water conservation savings; and c) the availability of alternatives land uses for fallowed crop land. On this last point, it is clear that land use plans must be in place in ensure that fallowed lands are not converted to urban uses that end up using as much water as the agricultural use.

Chapter I

Direct Costs of Conservation Policies

Introduction

This chapter presents a method for measuring the direct, farm-level impacts of agricultural water conservation policies and applies this method to the problem of reducing seawater intrusion in Monterey County. Possible conservation measures include fallowing, investment in low-volume irrigation technology, and changes in water management practices such as irrigation scheduling and irrigation consulting (i.e. the California Department of Water Resources' Mobile Lab facility).

This investigation begins with the premise, which is supported by an extensive body of empirical research, that farmers make rational water use decisions. That is, given current water price and availability, farmers use water in the way that maximizes profits. It follows from this hypothesis that growers will change their water use behavior only when underlying economic conditions change. For example, a farmer will look at slope, water holding capacity, crop type, depth to groundwater, electricity costs, labor costs, commodity prices, and other factors when choosing between alternative irrigation systems. A number of these factors, such as soil quality, cannot be influenced by a governmental agency; however, other factors such as the price of water can be varied by public policy. By varying the price of water and other economic factors, a public agency can encourage more or less conservation.

Encouraging water conservation by raising prices or reducing water availability would most likely reduce farm profits, and policies that aim to increase water use efficiency in agriculture impose costs on the farm economy. **The goal of this chapter is to measure the costs to farmers of stabilizing the seawater intrusion problem** through increased agricultural water conservation motivated by a number of alternative water pricing and availability policies.

Once these direct impacts are defined and measured, it is possible to compare the costs of conservation programs with the technical solutions contemplated by the County and other entities. The goal of comparing costs of various alternatives is to construct a portfolio of policy options that stabilizes seawater intrusion at minimum cost to the Salinas Valley economy.

Economic Impact Model

This section describes a method for measuring the short-term economic impacts of water policy changes, known as the "rationing" model (Sunding et al., 1995 a and b). The discussion in this study is mostly descriptive; for a mathematical description of the model, see Appendix 6. The model's name derives from its central feature: in the short-run, growers respond to changes in water allocations by fallowing land otherwise devoted to production of the lowest-value crops. The model allows growers to change their irrigation technologies in the long-run. This approach reflects the well-established fact that growers have a large degree of flexibility when they make long-term decisions regarding irrigation technology and cropping patterns, but have only limited flexibility in the short-run (see for example Zilberman et al., 1994 and 1995 on California farmers' response to the 1987-92 drought).

The Salinas Valley consists of many production environments that vary in terms of weather, land quality, water availability, and market conditions. Existing crop allocation patterns have evolved over time to maximize the overall benefits from agricultural production so that at each location, farmers have invested substantial capital in infrastructure, including equipment for harvesting, packing, and irrigation systems; growers also have highly region-specific human capital and long-term relationships with packers and distributors. As a result, crop mix choices are predetermined in the short-run and are profit-maximizing for individual locations. Reductions in water supply that change the preconditions for a successful crop mix are likely to be met in the short-run by ceasing production of the lowest-value crops.[1]

Another factor motivating the rationing approach is that there is evidence that the relationship between applied water and yield has the "fixed proportions" property within a given irrigation technology. Namely, below a certain level of applied water (the "crop water requirement"), there is a proportional relationship between yield and applied water per acre, and water application above the water requirement yields no additional output. This finding implies that farmers' short-run response to cuts in their surface water supplies is to either irrigate a field with the quantity of water required for maximum yield or not irrigate it at all.

The rationing model assumes that input and output prices do not change in response to conservation policies. This assumption is appropriate since only modest amounts of fallowing and technology adoption are associated with most of the conservation policies considered. With regard to output markets, while it is true that there are certain seasons and crops for which Monterey County has a large market share, Monterey County growers most often have many actual and potential competitors. As a result of this fact, and also from the relatively small changes in farm output associated with the conservation programs, food prices will most likely not change significantly in response to the conservation programs.

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[1] In this respect, the rationing model is an example of the "putty-clay" approach to production economics pioneered by Houthakker (1956) and Johansen (1972). The approach has been refined and applied to agricultural settings by Hochman and Zilberman (1978), Sunding et al. (1995a, b) and Zilberman et al. (1994). Putty-clay models treat production decisions as predetermined in the short-run by previous technology choices. For example, the water consumption of urban households is determined by the type of toilet and shower head used, the type of landscaping installed, and other factors that are generally variable only in the long-run. The notion that irrigation technology choice is conditioned by soil quality and availability of groundwater is well established in Caswell and Zilberman (1985 and 1986). In the long-run, however, growers can respond to changes in water availability and price by investing in alternative irrigation technologies and management methods.

The same is probably true of input prices. It is well known that Monterey County agriculture is intensive and employs many resources such as labor, chemicals, machinery and land. With regard to the non-land inputs, their price is not determined to any real degree by farming activity in the Salinas Valley. For example, it is unreasonable to expect the price of pesticides to change in response to a small amount of fallowing in King City.

It is more likely, however, that the price of land in the Salinas Valley may change as a result of the conservation programs. Most growers in the study area rent land and it is possible that the price of land may decrease in response to pumping charges and land taxes designed to increase conservation. While changes in rent are possible, we believe that significant changes are unlikely for several reasons. The conservation programs envisioned in this study only encourage a small amount of fallowing (for example, 2 percent of Valley agricultural land in the most efficient policy to reduce seawater intrusion by 25 percent). Further, the fallowing will occur only in the Pressure and Eastside areas where there are many alternative uses of land outside agriculture. Some landowners would rather devote their land to a non-agricultural use rather than cut rents to continue leasing their land to farmers; these are the lands where fallowing will most likely take place.

Definition of Basic Units

Salinas Valley agriculture is highly diverse both in terms of economic activity and environmental conditions. This region is one of the few agricultural areas in the United States where production occurs year-round, a by-product of its coastal location. Climatic conditions in the Valley vary widely between the northern, coastal region and the southern, upland region. Temperatures are fairly constant near the coast, and humidity is high throughout the year. Inland, temperatures fluctuate greatly between daytime and nighttime, particularly in the summer, and fluctuate between winter and summer. Soil conditions are also highly differentiated in the Salinas Valley, especially in terms of slope and water permeability.

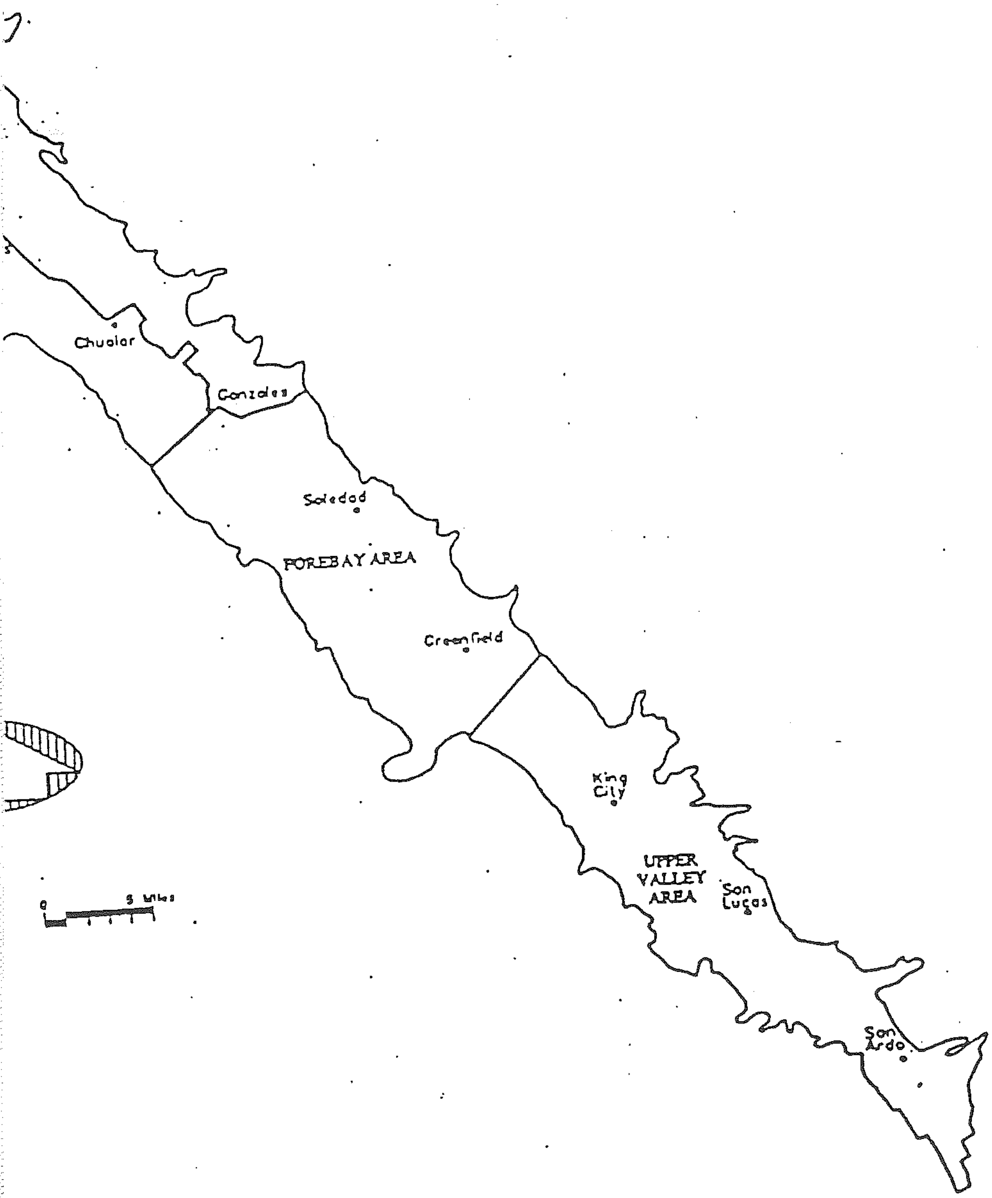
Most growers in the Salinas Valley produce vegetable crops for both the fresh and processed markets. These commodities must meet extremely strict quality standards in terms of insect damage and appearance, and processors have finely tuned evaluations of growers' varying abilities to produce high-quality output reliably. A high degree of expertise is required to produce these crops effectively, and as a result growers acquire a high degree of highly region- and crop-specific human capital over time.

The high degree of variation in agricultural production activities and environmental conditions in the Salinas Valley makes it imperative that an economic impact model developed for the Valley have a relatively high degree of detail. Recognizing these important factors, our impact model considers agricultural production disaggregated by crop, region and season.

The rationing model developed for the Salinas Valley has four geographic subareas: Pressure, Eastside, Forebay and Upper Valley (see Figure 1). These regions are identical to those defined in other hydrologic studies of the Salinas Valley, particularly those of the California Department of Water Resources and Montgomery Watson. Environmental and agronomic conditions are similar within these regions, but not necessarily among regions.

Finally, the rationing model disaggregates agricultural production by season: winter (harvested between December and February), spring (March to May), summer (June to August) and fall (September to November). Market conditions vary tremendously over the year for perishable vegetable crops, primarily due to weather conditions in competing regions. Water application also varies by season as effective

Figure 1



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Information on water use (Appendix Table 2-3) is taken from the Crop Calendar and Net Irrigation Water Use Model constructed by the US Bureau of Reclamation and the Monterey County Water Resources Agency in 1991. This model estimates applied water for each crop, region and season given existing irrigation technologies and disaggregated data on evapotranspiration, effective rainfall and other environmental factors such as soil type. Finally, average depth to groundwater for each region, which is used to calculate pumping costs, is taken from the Groundwater Flow and Quality Model Report issued by Montgomery Watson in 1994.

Pumping costs (Appendix Table 2-4) are measured using $0.25/acre foot/foot of lift as a unit pumping cost. This figure includes electricity charges as well as maintenance and depreciation, and is widely employed as a rule-of-thumb. Depth to groundwater by region is taken from Montgomery Watson's Groundwater Flow and Quality Model Report.

Costs of production for each of the farming activities (Appendix Table 2-5) conform to the standard University of California definitions for various cost categories. Data on production costs were gathered from published sources and in a series of interviews with Salinas Valley growers, commodity group representatives and University of California Cooperative Extension advisers conducted between February and May, 1995. Survey participants were asked to provide information on yields and costs of production by crop, region and season. This information was tabulated and averaged for each basic activity. A secondary survey of different growers was conducted in May to verify the accuracy of the production data.

The economic database used by the rationing model has a close fit with actual agricultural production activity in Salinas Valley. Adjusting for the fact that the crops included in our database account for less than 100 percent of total crop acreage, farm sales in our database are $1.95 billion per year; the latest Monterey County

Agricultural Commissioner report gives Salinas Valley farm revenues of $1.97 billion per year. Further, our database is consistent with groundwater pumping of 535,000 acre feet annually, which is the same amount calculated by Montgomery Watson's Integrated Groundwater-Surface Water Model (IGSM).

The most striking feature of the production data is the variation in net revenue, or farmer income, generated per acre foot of water applied in the Salinas Valley. Some crops such as strawberries generate several hundred dollars of farmer income per acre foot of water pumped, while other crops such as broccoli grown in the summer generate only a few dollars of income per acre foot of groundwater pumped. This heterogeneity suggests that a well-designed conservation program, or a program that results in minimum impact to the farm economy, will target only the lower-value uses of water for conservation. However, the existence of extreme variation in value produced with the water available in the Valley also suggests that a poorly designed conservation program can have disastrous consequences for the Valley farm economy by curtailing high-value uses of water.

Hydrologic Data

An important feature of Salinas Valley hydrology is that the effect of groundwater pumping on seawater intrusion varies by region. Because the goal of the study is to identify the policy that achieves a given seawater intrusion objective while minimizing the impact on agriculture in the valley, it is important to accurately capture the relationship between pumping and intrusion in the impact model. The hydrologic data is used to calculate seawater intrusion resulting from various farming activities.

To estimate the relationship between regional groundwater pumping and seawater intrusion, we performed a statistical analysis to summarize results from a groundwater study conducted by Montgomery Watson using IGSM (Taghavi, 1995).

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Table 1

Reduction of Net Revenue
($ '000)

Policy	Percent Reduction of Seawater Intrusion 10%	25%	50%
Region-Specific Pumping Charge (Ac/Ft)	139	313	1,995
Region-Specific Land Use Charge (Acre)	139	364	2,026
Uniform Pumping Charge (Ac/Ft)	557	771	5,711
Uniform Land Use Charge (Acre)	304	771	4,295
Tradable Groundwater Withdrawal Permits	557	771	5,711
Region-Specific Upper Pumping Limit (Ac/	2,028	5,069	10,138
Uniform Upper Pumping Limit (Ac/Ft/Ac)	4,068	10,169	20,338

Percentage Reduction of Net Revenue

Policy	Percent Reduction of Seawater Intrusion 10%	25%	50%
Region-Specific Pumping Charge (Ac/Ft)	0.1%	0.2%	1.5%
Region-Specific Land Use Charge (Acre)	0.1%	0.3%	1.5%
Uniform Pumping Charge (Ac/Ft)	0.4%	0.6%	4.2%
Uniform Land Use Charge (Acre)	0.2%	0.6%	3.2%
Tradable Groundwater Withdrawal Permits	0.4%	0.6%	0.4%
Region-Specific Upper Pumping Limit (Ac/	1.5%	3.7%	7.5%
Uniform Upper Pumping Limit	3.0%	7.5%	15.0%

Source: Agland Economic Model

Table 2

Charges to Achieve Percentage of Seawater Intrusion

Policy		Percent Reduction of Seawater Intrusion 10%	25%	50%
Region-Specific Pumping Charge	-North Valley	19.00	26.00	124.00
	-South Valley	0.00	0.00	0.00
Region-Specific Land Use Charge	-North Valley	20.00	26.00	125.00
	-South Valley	0.00	0.00	0.00
Uniform Pumping Charge	-Valley Wide	18.00	25.00	120.00
Uniform Land Use Charge	-Valley Wide	21.00	26.00	125.00

Source: Agland Economic Model

percent reduction. Charges in this case are $124 in the lower valley and $0 in the upper valley. Note that charges in the upper valley become positive only when conservation is used to reduce seawater intrusion by more than 75 percent. Finally, a 10 percent reduction in seawater intrusion can be encouraged through region-specific charges at a direct cost of only $139,000 per year by imposing pumping charges of $19 per acre foot in the lower valley and $0 in the upper valley.

The region-specific pumping charge results in modest amounts of fallowing (assuming no irrigation technology and management changes; these will be discussed below). For the 25 percent reduction scenario, this policy results in 16,517 fallowed acres, all of which occur in the lower valley. Recall that the rationing model works on the basis of crop acres (i.e. one acre with three rotations per year equals three crop acres). There are 380,523 crop acres in the Salinas Valley in the base case, so the region-specific pumping charge implies that only 4.3 percent of all crop acres are fallowed. The number of actual acres fallowed is even smaller, due to the fact that there are multiple rotations on many acres farmed. With an average of 1.6 plantings of vegetable crops per acre per year, the impact model calculates that only 2.7 percent of actual acres are fallowed in response to the pumping charges for the 25 percent reduction scenario.

Finally, note that while a charge of $26 per acre foot seems modest, this is a substantial increase in the price of water. Currently, most growers in the lower valley pay marginal pumping costs of close to $50 per acre foot if they draw from the 180 foot aquifer. Thus, a $26 per acre foot charge on top of current pumping costs is almost a 50 percent increase in the price of water. It seems likely that this large an increase can stimulate the small amounts of fallowing necessary to achieve conservation goals.

2) *Region Specific Land Use Charge for Groundwater Pumping*

The next policy considered is a regional per acre charge on groundwater pumping, defined simply as a per acre charge that varies among regions. The regional per acre charge is a significant improvement over the uniform per acre charge; the regional land use charge achieves the 25 percent reduction of seawater intrusion at a direct cost of $364,000 per year. This lost net income is close that of the regional per acre foot pumping charge policy, which results in lost net revenue of $313,000 per year. These results highlight the importance of a regional approach to water conservation to reduce seawater intrusion.

The non-uniform per acre charge required to achieve 25 percent reduction in seawater intrusion is $26 per acre in the north valley and $0 per acre in the south valley. As is the case with the region-specific volumetric charges, the upper valley charge is greater than zero only when conservation is used to slow seawater intrusion by more than 75 percent. The difference in the pumping charges between regions reflects the fact that while upper valley growers do contribute to the seawater intrusion problem, their marginal impact is far less than that of north county growers. Thus, in the least-cost solution, there should only be a small amount of conservation in the south valley relative to the amount of conservation in the north valley.

Finally, consider the costs of achieving 50 percent and 10 percent stabilization with region-specific land use charges. Region-specific per acre charges can slow seawater intrusion by 50 percent at a cost of $2.0 million annually; 10 percent reduction in seawater intrusion can be achieved at a cost of $139,000 annually. The 50 percent reduction scenario is achieved with a charge of $125 per acre in the lower valley and no charge in the upper valley; the 10 percent reduction scenario is achieved with a per acre charge of $19 in the northern valley and no charge in the southern valley.

3) *Uniform Pumping Charge*

The next policy option is a uniform pumping charge, which takes the form of a constant per-acre foot charge levied on all groundwater users in the Salinas Valley. This policy hits those crops in the southern valley disproportionately hard. The rationing model measures the annual direct cost (e.g. lost net revenue, or farmers' income) of this policy at $771,000 for the 25 percent reduction scenario, and calculates the requisite pumping charge as $25 per acre foot of water pumped. For the 50 percent reduction scenario, lost net revenue is $5.7 million and the pumping charge is $120 per acre foot. Finally, consider the scenario where seawater intrusion will be reduced by 10 percent through agricultural water conservation. In this case, net revenue falls by $557,000, and the pumping charge is $18 per acre foot.

The hydrologic model distinguishes clearly between pumping in the northern and southern portions of the Salinas Valley in terms of the marginal impact on seawater intrusion; pumping in the northern valley encourages far more seawater intrusion than pumping in the southern valley. It follows from this observation than a regional approach to water charges should be superior to uniform water charges since it fine tunes incentives to hydrologic conditions that Montgomery Watson has shown to vary among regions.

Remember that these lost net revenues are for the conservation program alone; the impacts of the other components of the overall program to reduce seawater intrusion, especially physical infrastructure, must be added to the costs of the conservation program.

4) *Uniform Land Use Charge for Groundwater Pumping*

The next conservation policy considered is a valley-wide charge levied on each acre farmed for the right to pump groundwater. This charge would be paid every time a crop is planted. Thus, if an acre is planted once a year (as is the case for perennials), then the charge is paid once; if the operator decides to double crop the acre, then the charge is paid twice, and so on. These land use charges encourage water conservation by making some farming activities unprofitable, thereby reducing groundwater pumping as they are curtailed.

Uniform per acre charges achieve the goal of stabilizing seawater intrusion at direct costs similar to pumping charges. For the 25 percent scenario, the model measures lost net revenue under uniform per-acre pumping charges at $771,000 annually, and calculates the requisite per acre charge as $26. The southern areas (Forebay and Upper Valley) fare better under per acre charges than under volumetric pumping charges since crops planted in these areas use more water per acre than those in the northern valley and are thus relatively more affected by pumping charges than by per acre charges.

For the 50 percent reduction scenario, lost net revenue is $4.3 million annually under the uniform per-acre pumping charge. The 10 percent reduction goal can be achieved with lost net revenue of $139,000 annually. Charges for these scenarios are $125 per acre to achieve 50 percent reduction in seawater intrusion through conservation and $21 per acre to achieve 10 percent reduction.

It should be noted that the per acre pumping charge does not provide incentives for farmers to change their irrigation technology and management practices; per acre pumping charges achieve conservation only through fallowing. This point is elaborated in the section below on irrigation technology and management, where we argue that volumetric charges are superior to per-acre charges, even though the two policies have similar short-run direct impacts.

5) Tradable Groundwater Withdrawal Permits

There is another interpretation to the uniform pumping charge scenario. It is possible to achieve water conservation through a pumping permit trading scheme. In this policy, each grower in the Valley would be given a permit to pump some number of acre feet annually. Growers could then use their permit, sell a portion of their entitlement on a free market to another grower, or buy pumping rights on the market. The net result of this permit trading scheme, which is quite similar to other environmental permit programs presently in use, is to increase the price of pumping in exactly the same way as a pumping charge, resulting in the same final allocation of pumping as the uniform charge.

6) Region-Specific Upper Pumping Limit

Region-specific pumping limits perform better than uniform pumping limits, but are still much less efficient that either the per acre or per acre foot pumping charges. The region-specific pumping limit can achieve the 25 percent reduction goal with lost net revenues of $5.1 million annually, which is more than 10 times greater than lost net revenues from either of the region-specific charge programs. Region-specific pumping limits can achieve the 50 percent reduction goal at a direct cost of $10.3 million per year and can achieve the 10 percent reduction goal at a direct cost of $2.0 million annually.

7) Uniform Upper Pumping Limit

The next policy option is a uniform pumping restriction wherein all growers in the Salinas Valley are required to cut their pumping relative to baseline levels by some percentage. The economic costs of this program are large as it is indiscriminate and affects high- as well as low-value water applications. The rationing model measures lost net revenue from a uniform pumping restriction that reduces seawater intrusion by 25 percent as $10.2 million annually. For the 50 percent reduction scenario, net revenue losses are $20.3 million per year and for the 10 percent reduction scenario loses are $4.1 million annually.

Economic losses from a uniform pumping restriction are large because this policy ignores the differences among farming activities in terms of their marginal contribution to seawater intrusion and the economic value produced with the water applied. Cutting pumping by some percentage in the coastal zone achieves a larger reduction in seawater intrusion than cutting pumping by the same percentage in the Upper Valley. Whereas the efficient solution recognizes this well-established hydrologic fact, the uniform pumping restriction does not. Note also that the uniform pumping limit also requires installation of groundwater meters and a constant program of monitoring and enforcement. These costs should be added to the net impacts calculated by the rationing model.

8) Tiered Groundwater Pricing

Tiered pricing is an administratively costly approach to agricultural water conservation that has had at best mixed results in agriculture. The goal of tiered pricing schemes is to encourage uniformity in water application by designing "break points" at which per acre foot water charges increase sharply. These pricing structures are commonly used in prices for residential electricity and natural gas usage.

The wisdom of tiered pricing in agriculture is highly suspect for several reasons. Analytically, tiered pricing is only justified if there is an increasing marginal cost of supply. A groundwater use system such as that in the Salinas Valley does not have this characteristic. Further, as was discussed earlier, environmental conditions such as soil quality and crop choice determine water use on a micro level, and to the extent that these factors vary widely between fields, the informational value of the break point is small. Finally, tiered pricing is expensive to implement as it requires the installation of groundwater meters and constant monitoring to determine cumulative pumping. Thus, tiered pricing is dominated by other available alternatives in the situation considered here.

9) Irrigation Technology Improvements

A different type of conservation policy involves regulating irrigation technology directly instead of regulating water applications. For example, Best Management Practice regulations specify how water should be used in addition to regulating the amount used. Alternatively, the County could use revenues generated by the charges discussed earlier to subsidize the price of low-volume irrigation technologies or irrigation consulting services, thereby accelerating adoption of water-conserving hardware and software. These subsidies can be powerful incentives to change water management practices, as has been shown elsewhere (Caswell and Zilberman 1985 and 1986; Green et al., 1995).

It is desirable to encourage technology and management changes in the lower valley for the same reason that it is desirable to encourage fallowing in the lower valley, simply because the costs of conservation are justified by the benefits only in this region. Currently, there is a high rate of drip adoption in strawberries grown in the lower valley and thus little scope for further irrigation efficiency gains. The same is also true of grapes, of which there are only 4,226 acres in the lower valley in any case. Thus, the most significant technology adoption and management improvement opportunities exist in vegetable crops (broccoli, head and leaf lettuce, cauliflower and celery) grown in the lower valley. A total of 137,170 crop acres are planted with these five vegetables in the lower valley. They use 157,285 acre feet of water annually and generate net farm revenues of $32.8 million per year.

The goal of this section is to measure the direct net revenue costs of improvements in irrigation technology for this subset of crops in the lower valley. Fortunately, there is extensive experience with modern irrigation methods in the Salinas Valley, and the resulting data can be applied here. The costs of changing irrigation technology and methods will be estimated assuming that a certain number of growers adopt a combination drip/sprinkler system.

Water applied to crops in excess of crop evapotranspiration either percolates to the aquifer, where it can be reused, or evaporates. Any decrease in evaporation caused by changing irrigation technology and management decreases net withdrawals from the aquifer and increases net aquifer storage. University of California farm advisers in Salinas and researchers at UC Davis report that drip/sprinkler irrigation in the Salinas Valley would reduce evaporation by 0.17-0.24 acre foot per acre. This decrease in evaporation implies that 80 percent of the acres planted to the five vegetable crops in the lower valley must be outfitted with drip/sprinkler systems to reduce seawater intrusion by 15-25 percent.

These same experts report that up to 15 percent yield improvements are associated with drip adoption due to the increased precision with which chemicals can be delivered to plants and the fact that drip systems discourage weed growth. We use a conservative estimate of 10 percent yield improvements, an estimate that is supported by a large body of evidence from actual field experience.

Dale (1995) estimates that a sprinkler/drip system costs $106 per crop acre more per year than a sprinkler system alone. The additional costs are primarily annualized capital expenditures on pumping and filtration equipment and also include marginal expenditures on drip tape. These additional per crop acre costs are net of the value of applied water savings.

Using these cost and relative efficiency estimates, the farm-level net revenue losses of reducing seawater intrusion by 25 percent through irrigation technology changes amounts to $7.1 million annually. Again, the program goal of achieving a high rate of technology adoption and water management changes can be achieved either by mandate or through a charge/subsidy program. While the farm-level costs of this program appear high relative to the regional charge schemes that encourage fallowing, it is crucial to remember that the indirect impacts of technology adoption are very small, and may well even be positive. The same is not true of the policies that encourage fallowing, which sometimes have large indirect costs, particularly in terms of lost farmworker jobs.

Discussion

The results of this analysis show that agricultural water conservation is a viable component of an overall program to stabilize seawater intrusion in Monterey County. We estimate that water conservation alone can reduce 25 percent of seawater intrusion at a direct cost to Salinas Valley farmers sector of $313,000 per year under either of the region-specific charges. Above all, this analysis demonstrates the importance of a regional approach as opposed to a uniform policy that treats all growers equally, regardless of their contribution to the seawater intrusion problem.

In choosing between the two regional charges considered here, it is important to remember that per acre groundwater pumping charges do not require metering of wells.

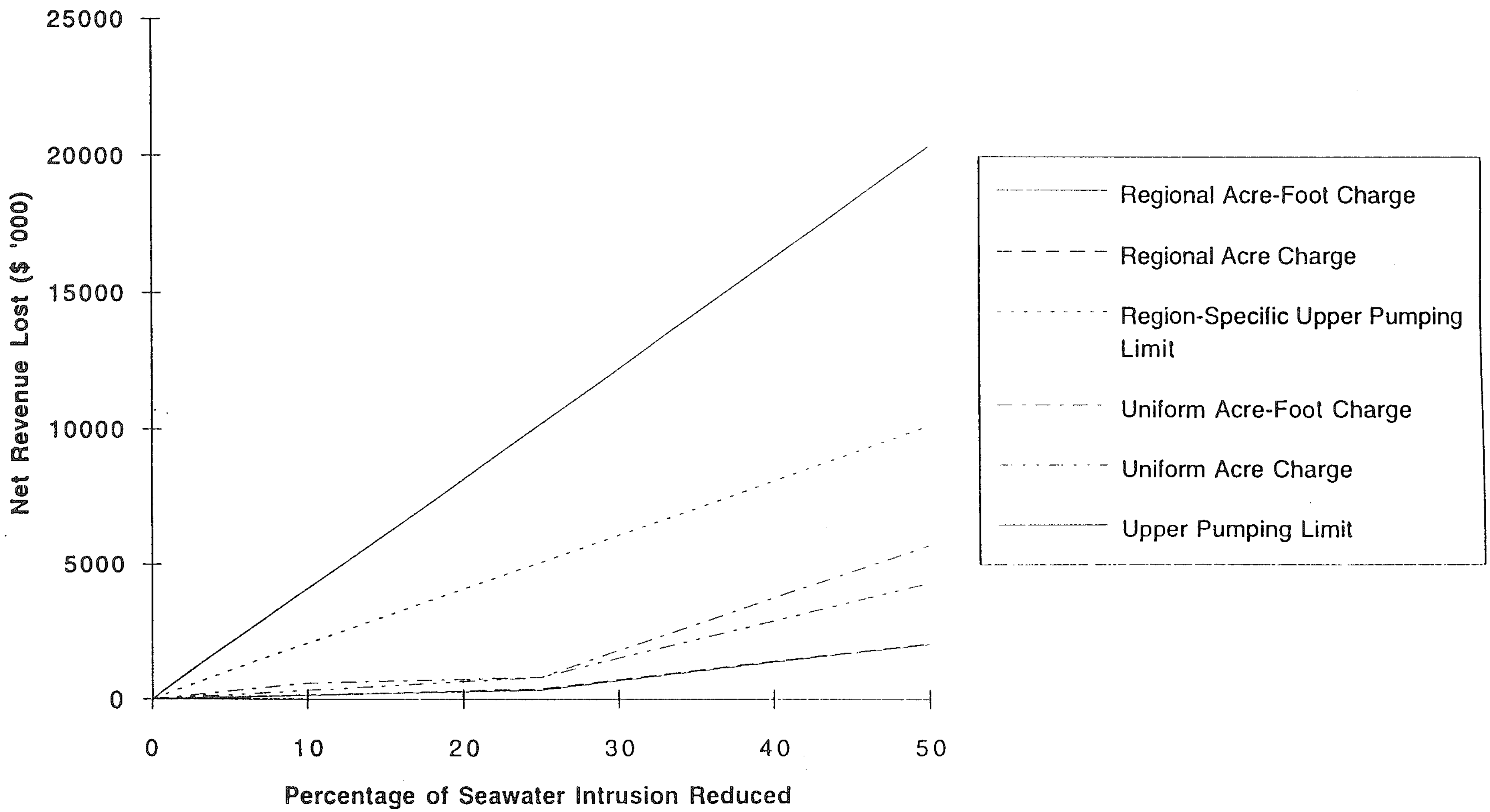
Thus, per acre pumping charges avoid significant legal, institutional and technical difficulties and have virtually the same direct cost as per acre foot charges. This result is not universal; indeed, there are many situations where water conservation is achieved at lower direct cost through the use of volumetric pricing.

While the direct net revenue losses from the regional per acre and volumetric charges are similar, recall that the short-run rationing model used to generate these impacts does not consider changes in irrigation management and technology; these are longer term responses to changes in water price and availability. It is likely that growers will respond to per acre foot charges by fine tuning their water application practices. For example, growers can use Mobile Lab facilities, pay more attention to CIMIS weather reports when scheduling irrigations and hire consultants to assist in irrigation hardware and software design. Per acre charges do not provide any incentive to apply water more efficiently since the charge is invariant with respect to actual water use (except that it equals zero when no water is pumped at all). For this reason, we advocate the use of region-specific volumetric pumping charges to stimulate agricultural water conservation in the Salinas Valley.

The results generated by the rationing model can be used to determine how agricultural water conservation can contribute to a multifaceted program that uses many tools to stabilize seawater intrusion. For example, there are a number of physical projects that can slow or stop seawater intrusion and agricultural water conservation can complement these other approaches.

Figure 2 shows that the total cost of conservation increases with the percentage of seawater intrusion abated for all policies. Further, this Figure shows that marginal costs increase at close to 25 percent reduction for the charge-based policies, indicating that some reduction in seawater intrusion can be achieved through conservation at relatively minimal cost to the agricultural economy.

Figure 2: Reduction in Net Revenue and Seawater Intrusion



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The composition of the least-cost bundle of conservation and physical solution alternatives also depends on whether the marginal cost of the physical solution increases with the percentage of seawater intrusion abated. If there are significant economies of scale associated with the physical solution (i.e. if the average cost of the physical solution decreases with the amount of seawater intrusion reduced), then it may well be preferable to adopt either the physical solution or the conservation solution. However, if the cost of the physical solution can be significantly reduced by scaling back the size of the project, then it may be desirable for the County to combine agricultural water conservation with an engineering solution.

Chapter II
Indirect Costs of Conservation Policies

Overview of Methodology

Implementation of ground water conservation strategies in the Salinas Valley would result in somewhat reduced crop acreage and crop production in the County. The magnitude of reduction is a function of the policy option (conservation strategy) pursued and the intensity of implementation of the strategy. Reduced crop acreage, in turn, results in reduced total sales of crops. This reduction in sales from the vegetable and fruit production sectors of the county can be viewed as the direct economic effect of ground water conservation. The purpose of this section of the report is to estimate the subsequent regional (i.e., county-wide) economic impacts brought about by the initial or *direct effect*. Impacts will be discussed in terms of county-wide changes in personal income and employment.

Regional economic impacts occur because of the ripple effect or re-spending patterns of inter-sectoral transactions within the county economy. In the course of vegetable or fruit production, for instance, goods and services are purchased from other sectors within the county economy. Likewise, fruit and vegetable commodities are sold as intermediate products to other sectors (notably, the food processing sector) and as sales to "final demand" which include household consumption, government purchases, and exports outside of the county. In the event of changes in fruit and vegetable production, these *indirect effects* occur in response to commensurate changes in purchases by and from the fruit and vegetable production sectors.

Direct and indirect changes in sectoral production lead to changes in total household income due to changes in total wage payments. Changes in purchases resulting from household income changes are defined as *induced effects*. The total regional economic impact is defined as the sum of direct, indirect and induced effects.

Regional economic impacts are commonly estimated through use of impact multipliers derived from input/output (I/O) models. For this study, we have used a county-level I/O model generated with IMPLAN/Q (1992 data). The IMPLAN/Q county model provided pertinent income and employment multipliers as well as tabular descriptions of the inter-sectoral linkages between agricultural commodity production and the rest of the county economy. The magnitude of 1992 inter-sectoral transactions tied to fruit and vegetable production and sale were derived by applying the proportional relationships of the I/O tables to the known levels of vegetable production available from Monterey County Agricultural Commissioners Reports. Direct impacts of the ground water conservation alternatives were deflated to 1992 dollars.

I/O procedures such as the use of multipliers are designed to be applied to direct economic perturbations that are expressed in terms of changes in sales to final demand for one or more target sectors. I/O multipliers are designed to describe the "backward-linked" indirect and induced effects throughout the regional economy that are brought about by the initial change in sales to final demand. For instance: a reduction in vegetable exports triggers reduced purchases of goods and services--including labor--by the vegetable production sector. Reduced production by sectors supplying goods and services to the vegetable production sector means, in turn, reduced purchases by those sectors, and so on. In the case of modeling the regional economic implications of reduced ground water availability for crop cultivation, we are faced with a supply-induced rather than demand-induced perturbation, also known as a "forward-linked" effect.

As I/O multipliers cannot be validly applied to supply-induced perturbations, it is necessary to translate the supply-induced perturbation into an equivalent or resultant change in sales to final demand for the affected agricultural sectors. That is, reduced vegetable production in response to constrained ground water deliveries does not all translate to reduced sales of vegetables to final demand. Some of the reduction, for instance, will be in the form of reduced sales of vegetables as intermediate products to other sectors in the county economy; and the same for fruit. Depending upon the extent to which reduced raw fruit and vegetable deliveries to the processing sectors can be offset by import substitution, the reductions in fruit and vegetable production will result in reduced production--and sales to final demand--from the processing sectors.[3] By using inter-industry transaction data available in IMPLAN/Q reports, we traced the most significant intermediate transactions involving fruits and vegetables in order to arrive at more accurate estimates of likely changes in sales to final demand that would be triggered by reduced ground water availability. In brief, this tracing of forward linkages means that water conservation triggers reduced sales to final demand from both agricultural production and processing sectors. Income and employment multipliers for both types of sectors are then applied after reduced sales to final demand have been estimated.

Fruit and Vegetable Production Within the Monterey County Economy[4]

In absolute terms and in relative terms compared to state-wide breakdowns, the fruit and vegetable production sectors are extremely important components of the Monterey County economy. Vegetable production in 1992 was $1.25 billion with fruit production at $250 million. Monterey County leads the state in production of several fruit and vegetable crops including lettuce, broccoli, cauliflower, and strawberries. Almost 20 percent of the land area of Monterey County is under fruit and vegetable cultivation. Fruit and vegetable production directly supports almost 30,000 jobs within

[3]We used the conservative assumption that vegetable and fruit processors have little short-term ability to substitute for reduced Monterey County raw fruit and vegetable deliveries through increased imports from outside of the county.

[4]Data sources: Economic Importance of Agriculture in Monterey County by Goldman, et al, and the 1992 Monterey County Agricultural Commissioners Report.

the county, accounting for over 20 percent of total county employment. Fruit and vegetable production accounts for 15 percent of total county personal income. Over the past 40 years, the real value of production has increased substantially as has the share of national and state-wide production attributable to Monterey County.

Inter-Sectoral Transactions with the Vegetable Production Sector

For every dollar of vegetable sector production in the county[5], producers purchase $0.21 in goods and services from other sectors in the Monterey economy and $0.05 from suppliers outside of the county. There are almost 100 sectors of the county economy that supply goods and services to the vegetable production sector.[6] For every dollar of production, the vegetable sector pays out $0.08 in wages and employee benefits and $0.01 in indirect business taxes. Of the total value of vegetable sector production, 74 percent is value added (i.e., profits, taxes, and employee compensation). Sixty-five percent of the total vegetable sector production value is attributable to proprietary and other property income.

[5]According to IMPLAN 1992 industry balance sheet data for Monterey County, the vegetable sector (Sector 18) accounts for 100 percent of all vegetable production in the county as well as minor amounts of production of commodities/services in two other sectors (ag/forest/fishing and amusement/recreation). Ninety-eight percent of the value of production from Sector 18 is associated with vegetable production.

[6]The IMPLAN framework entails 258 sectors, not all of which may be active in any one county.

IMPLAN commodity balance sheet data for 1992 reveals the following breakdown in Monterey County vegetable sales:

Deliveries To:	% of Total Production
Food Processing Sectors	1.1%
Household Consumption	4.0%
Inventory Addition	0.6%
Foreign Exports	8.1%
Domestic Exports	86.1%

Sales to final demand constitutes 98.9 percent of total production, with the preponderance being exports (94.2 percent). From these data, it is evident that vegetable processing (e.g., canning) is not a significant industrial activity in Monterey County.

Inter-Sectoral Transactions with the Fruit Production Sector

For every dollar of sales from the fruit production sector (IMPLAN Sector 16)[7], producers make purchases of goods and services totaling $0.05 from other sectors in the county. Purchases of goods and services from outside the county total $0.02 per dollar of fruit sector sales. Relative to vegetable production, then, fruit production is less reliant upon other industrial sectors of Monterey County. For every dollar of sales, the fruit production sector pays $0.18 in wages and employee benefits, which is

[7]Similar to the vegetable production sector, IMPLAN 1992 industry balance sheet data reveal that the fruit sector account for 100 percent of Monterey County fruit production and minor amounts of production of commodities and services in three other sectors (ag/forest/fishing, dehydrated food products, and amusement/recreation). Eighty-seven percent of the sales from Sector 16 is associated with fresh fruit sales.

over twice that of the vegetable production sector. This difference is an indication that fruit production is substantially more labor intensive than vegetable production. Indirect business taxes total $0.02 per dollar of fruit production sector sales. Of the total value of fruit sector production, 94 percent is value added (i.e., profits, taxes, and employee compensation). Seventy-four percent of the total fruit sector production value is attributable to proprietary and other property income.

IMPLAN commodity balance sheet data for 1992 reveals the following breakdown in Monterey County fruit sales:

Deliveries To:	% of Total Production
Food Processing Sectors	28.2%
Household Consumption	19.2%
Inventory Addition	0.8%
Foreign Exports	20.6%
Domestic Exports	31.0%

Compared to the vegetable production sector, these data reveal that the exports constitute a substantially smaller portion of total fruit production (51.6 percent compared to 94.2 percent). This difference is associated with substantially higher sales to the processing sectors and to household consumption. The former is an indication that fruit processing is substantially more significant in Monterey County as compared to vegetable processing. So whereas the vegetable production sector is more linked with the county economy with respect to purchases of goods and services, the fruit production sector is substantially more linked to the county economy with respect to sales to other sectors and with respect to payments to labor.

Results

As shown in Table 3, seven policy options for limiting or stabilizing seawater intrusion into the Salinas Valley aquifer will result in a reduction in crop production and a commensurate impact on the regional economy. The larger the extent of reduction in seawater intrusion, the greater the direct economic impact on the agriculture sector and total impact on the regional economy. As shown in Table 3, a 10 percent reduction of seawater intrusion by means of the conservation policy options described in this report can result in a reduction in vegetable and fruit sales of between $27.7 million for the most efficient policy and $104.5 million for the least efficient policy. This loss--constituting a 1 percent to 5 percent reduction from 1992 crop sales -- would be brought about by a roughly 2 percent to 4 percent reduction of crop acres in the county. The regional impact (direct, indirect, and inducted impact on employment) for this example would be between $51.9 million for the most efficient policy and $195.5 million for the least efficient policy. The direct impact, in turn, would trigger county-wide losses in employment of an estimated 734 jobs (Table 4) for the most efficient policy and up to 2,763 jobs for the least efficient policy. This represents between 1-4 percent of the jobs in the agricultural sector.

Table 3 Impact of Conservation Options Upon Sales In Monterey County

Policy Options	Percent Reduction of Seawater Intrusion 10%	25%	50%
1. Region Specific Pumping Charge (acre foot)			
Reduction in Farm Sales ($000 (1)	27,739	70,262	161,315
Proportion of Total Farm Sales (%)	1%	4%	8%
Direct, Indirect and Induced Impact on Sales ($000)	51,930	131,537	301,998
2. Region Specific Land Use Charge (acre)			
Reduction in Farm Sales ($000 (1)	27,739	70,262	158,512
Proportion of Total Farm Sales (%)	1%	4%	8%
Direct, Indirect and Induced Impact on Sales ($000)	51,930	131,537	296,750
3. Uniform Pumping Charge (acre foot)			
Reduction in Farm Sales ($000 (1)	104,454	146,406	364,414
Proportion of Total Farm Sales (%)	5%	8%	19%
Direct, Indirect and Induced Impact on Sales ($000)	195,548	274,087	682,219
4. Uniform Land Use Charge (acre)			
Reduction in Farm Sales ($000 (1)	60,921	146,406	313,512
Proportion of Total Farm Sales (%)	3%	8%	16%
Direct, Indirect and Induced Impact on Sales ($000)	114,050	274,087	586,926
5. Tradable Groundwater Withdrawal Permits (acre foot)			
Reduction in Farm Sales ($000 (1)	104,454	146,406	364,414
Proportion of Total Farm Sales (%)	5%	8%	19%
Direct, Indirect and Induced Impact on Sales ($000)	195,548	274,087	682,219
6. Region Specific Upper Pumping Limit (acre foot per acre)			
Reduction in Farm Sales ($000 (1)	40,118	100,294	200,588
Proportion of Total Farm Sales (%)	2%	5%	10%
Direct, Indirect and Induced Impact on Sales ($000)	75,105	187,760	375,521
7. Upper Pumping Limit (acre foot per acre)			
Reduction in Farm Sales ($000 (1)	57,938	144,845	289,690
Proportion of Total Farm Sales (%)	3%	7%	15%
Direct, Indirect and Induced Impact on Sales ($000)	108,466	271,164	542,329

Source:
(1) Data generated from model used in Chapter 1.
Other information derived from analysis using IMPLANQ.

Table 4 Impact of Conservation Options Upon Employment in Monterey County

Policy Options	Percent Reduction of Seawater Intrusion		
	10%	25%	50%
1. Region Specific Pumping Charge			
Reduction in Farm Employmen (1)	305	772	1,772
Proportion of Total Farm Employment (%)	1%	2%	5%
Direct, Indirect and Induced Impact on Employment	734	1,858	4,266
2. Region Specific Land Use Charge			
Reduction in Farm Employmen (1)	305	772	1,741
Proportion of Total Farm Employment (%)	1%	2%	5%
Direct, Indirect and Induced Impact on Employment	734	1,858	4,192
3. Uniform Pumping Charge			
Reduction in Farm Employmen (1)	1,147	1,608	4,002
Proportion of Total Farm Employment (%)	4%	5%	12%
Direct, Indirect and Induced Impact on Employment	2,763	3,872	9,638
4. Uniform Land Use Charge			
Reduction in Farm Employmen (1)	669	1,608	3,443
Proportion of Total Farm Employment (%)	2%	5%	11%
Direct, Indirect and Induced Impact on Employment	1,611	3,872	8,292
5. Tradable Permit			
Reduction in Farm Employmen (1)	1,147	1,608	4,002
Proportion of Total Farm Employment (%)	4%	5%	12%
Direct, Indirect and Induced Impact on Employment	2,763	3,872	9,638
6. Region Specific Upper Pumping Limit			
Reduction in Farm Employmen (1)	441	1,102	2,203
Proportion of Total Farm Employment (%)	1%	3%	7%
Direct, Indirect and Induced Impact on Employment	1,061	2,653	5,305
7. Upper Pumping Limit			
Reduction in Farm Employmen (1)	636	1,591	3,182
Proportion of Total Farm Employment (%)	2%	5%	10%
Direct, Indirect and Induced Impact on Employment	1,532	3,831	7,662

Source:
(1) Data generated from model used in Chapter 1.
Other information derived from analysis using IMPLANQ.

An eighth policy option for limiting seawater intrusion, irrigation technology and management improvements, would result in a minimal reduction in crop production and is therefore not estimated to have a substantial impact upon the regional economy. In general, the regional impacts of this option would vary depending upon the source of funds used to pay for the technology, and the impact of the technology upon crop yield. If the irrigation technology were purchased by farmers from the farm equipment sector, it would represent a drop in farm sector income and a rise in farm equipment sector income, with largely offsetting effects. Increases in yield associated with irrigation technology would cause an increase in farm sales, with generally positive impacts upon farm income and the regional economy.

The fundamental conclusions to be reached from these estimates are:

1) most of the conservation policy options to decrease seawater intrusion described in this chapter impose a significant cost in terms of the agricultural sector's direct, indirect and induced contributions to the regional economy. However, this cost should be compared to the cost of alternative methods of stabilizing seawater intrusion to determine the relative merits of each method.

2) irrigation technology and management improvements would result in a minimal reduction in crop production and are estimated to have a negligible impact upon the regional economy.

A Note About These Results

The analysis in this Chapter was based upon the assumption that crop prices, and other variables that describe inter-industry transactions within Monterey County, do not change. This assumption is fundamental to the use of IMPLAN, and most other models for estimating indirect economic impacts of policy options upon a regional economy. However, the assumption is also frequently violated when large economic impacts are anticipated from a policy option. In that case, regional economic impact estimates need to be considered with great caution.

The economic impacts predicted in this Chapter would likely affect the structure of the Monterey economy to some degree. To take one very important example, crop production declines anticipated in Chapter 1 would probably affect crop prices to a degree. This conclusion is supported by statistical studies of the price elasticity of California vegetables (Studies at the California Department of Water Resources suggest that a 20 percent decline in State vegetable production would raise vegetable prices almost 100 percent). The conclusion is also supported by the experience of Monterey farmers this winter, when flooding and production losses caused a dramatic rise in vegetable prices.

It was beyond the scope of this project to estimate changes in crop prices. However, it is likely that a rise in prices would help to offset many of the adverse economic impacts estimated in Table 3.

Chapter III

Policy Directions and Recommendations

Introduction

There are a wide variety of policies available for dealing with the seawater intrusion problem in the Salinas Valley. These include the agricultural conservation policies described in this study (pumping charges, land use charges, pumping limits, and irrigation adoption measures), as well as the water supply management policies and the urban demand management policies described elsewhere. An important task facing Monterey County is to choose an appropriate mix of these policies for adoption.

Three Criteria For Assessing Water Demand and Supply Management Policies

The County is evaluating various policies to limit seawater intrusion. We believe that an important goal of the evaluation process should be to come up with the information needed to select the best mix of policies (the program) needed to stabilize seawater intrusion at minimum economic cost to the region. In order to do this, at least three evaluation criteria should be adopted:

1. **Evaluations should cover a comprehensive range of the important policy options.** Evaluations should be comprehensive to help insure that high cost policies are not followed when lower cost policies are available to do the same job.

2. **Evaluations should be made of each policy option for different sizes of that option.** The second criteria is suggested because several policy options are available and the County needs to vary the size of each policy as needed to minimize the overall costs of their seawater intrusion program.

3. **Evaluations should include both direct and regional costs of each policy option.** The third criteria is recommended because the direct and regional costs of some options vary a great deal and the County may need to consider both costs before choosing a least cost policy mix (program).

Evaluation of Agricultural Conservation Policies

This study includes an analysis of a range of agricultural conservation policies, including region specific and uniform pumping charges, land use charges, and upper pumping limits to influence crop acreage in Monterey County.[1] The study also includes an evaluation of a policy to influence agricultural irrigation technology and management. We feel that the range of policies we have evaluated is sufficiently comprehensive to provide a good sense of the potential role of agricultural conservation in stopping seawater intrusion. Estimates of the direct and regional costs of these policies have been provided in Chapters 1 and 2 respectively. To show how these costs vary with the scale of each policy, estimates are provided to indicate direct and indirect costs assuming three different project sizes (see Tables 1-4).

Based upon this evaluation of agricultural conservation policies we have drawn five principal conclusions:

1) Agricultural conservation policies should be designed in a way that imposes the lowest possible direct cost to farmers and the lowest possible indirect cost to the regional economy.

2) This goal is best accomplished with region-specific and season-specific land use or pumping charges. Such charges can be tailored to influence cropping patterns during

[1]In addition, a secondary evaluation of the uniform upper pumping limit was performed assuming a market was available to trade permits to pump water.

seasons when the costs of fallowing are lowest, and in regions where the benefits of fallowing are greatest.

3) The unit cost of conservation appears to increase with the size of the conservation program. These costs rise relatively rapidly when over 3 percent or 4 percent of crop acres are fallowed in the County. We have limited our analysis to conservation programs that solve fifty percent or less of the seawater intrusion problem.

4) Our studies suggest that the direct cost of the fallowing policies to the farmer is in the range of $20-$40 per crop acre, with relatively high regional and indirect costs. In comparison, our study suggests that the direct cost of programs to improve irrigation management and technology is $106 per irrigated crop acre. However, the regional and indirect costs of this policy are much lower, because agricultural land is kept in production. When the water quality benefits of improved irrigation to the region are included, the regional impacts of this policy may well be positive.

5) Because policies which encourage crop fallowing may impose high regional costs, we recommend they be implemented cautiously, using relatively low land use or pumping charges.(e.g. $20 per acre). We further recommend that proceeds from land use or pumping charges be used to encourage improved irrigation management and technology adoption. We suggest that a program of modest charges to encourage crop fallowing, combined with subsidies to encourage better irrigation management, is one of the more promising options available to the County that should be given further consideration

Additional Information Needed to Integrate Agricultural Conservation with Urban Conservation and BMP Engineering Policies to Limit Seawater Intrusion

We feel our work is sufficiently comprehensive to indicate a potentially useful and important role for agricultural conservation in the County's overall program to stabilize seawater intrusion. However, we also feel that additional studies remain to be completed before the least cost mix of agricultural and non-agricultural policies to stabilize seawater intrusion can be chosen. These include studies of:

1) the cost of smaller BMP engineering alternatives (scaled to be compatible with agricultural conservation programs proposed in this report).

2) the cost of urban water conservation savings

3) the availability of alternative land uses for fallowed crop land

4) water conservation and quality benefits of improved irrigation management and technology adoption.

It is likely that some combination of BMP engineering alternative and agricultural conservation will be chosen as the principle approach for stabilizing seawater intrusion. However, at this stage we do not feel it is possible to determine the appropriate least cost mix between BMP and agricultural conservation in this approach. In general, the proportion of agricultural conservation in this mix will be determined by comparing the cost of various levels of the chosen BMP alternative with the cost of similar levels of agricultural conservation. We cannot make this comparison until more information is made available showing the cost , and returns to scale, of different levels of the BMP alternatives.

For example, it may be cost effective to increase the scale of agricultural conservation if the engineering alternatives become relatively expensive as they get larger. Similarly, the scale of agricultural conservation should be decreased if the BMP engineering alternatives become relatively inexpensive as they get larger.

In addition, more information is needed of the cost and effectiveness of aggressive urban water conservation in Monterey County. The recent drought has demonstrated the large water savings made possible by urban conservation in many parts of the State. In some large urban areas drought period conservation effectively decreased overall water use by over 40%. If additional agressive conservation policies in Monterey County have the potential to achieve such large water savings they should given careful consideration as a cost effective means to limit seawater intrusion.

Appendix 1: Terms of Reference

Proposal by Agland Investment Services, Inc.
(Revised December 6, 1994)

SOCIO-ECONOMIC ANALYSIS
SALINAS RIVER BASIN MANAGEMENT PLAN EIR

I. BACKGROUND

Agland Investment Services, Inc., after an initial interview, was asked by EDAW to submit a proposal to the Monterey County Water Resources Agency to undertake a **socio-economic analysis** as part of the Salinas River Basin Management Plan EIR.

While EDAW has been contracted to prepare the EIR on the preferred alternatives for the Salinas River Basin Management Plan, the socio-economic impact of the proposed solutions on agriculture, the agribusiness sector, and the economy of Monterey County has been of increasing concern in the County. It would appear that the public will request that the socio-economic impact study of the project be undertaken. This study needs to be undertaken by an organization such as Agland Investment Services with specialized experience in this area.

II. THE PROJECT

A. Introduction

The water situation in the Salinas Valley is critical. Seawater intrusion into the aquifer and nitrate contamination are creating problems that cannot be ignored. While a general consensus has been reached on the need for a solution, the economic impact of the various measures for solving the problem and the impact of the proposed cost allocation for the program remain somewhat unclear. However, it is possible to estimate the major economic impacts of proposed solutions and explore alternative measures which might mitigate the adverse economic impacts. **The goals of the socio-economic analysis would be:**

1) To estimate the economic impact of proposed measures on various sectors of the economy; and
2) To determine which additional measures would be the most effective in softening the adverse economic impacts.

This requires building a spreadsheet model to estimate the direct economic changes of proposed alternatives (measured largely in changes of agricultural output) and then using the results of this model in a regional input-output model to estimate the changes in the regional economy. **In general, the model is a tool for decision-makers and the public to better understand the economic consequences of different types of actions aimed at solving the water problems in the Salinas Valley.** Agland will also work with the EDAW team to investigate the environmental consequences of the socio-economic impacts of the alternatives.

II. How MCWRA's "Options for Conservation Alternatives" Will Be Covered in Agland's Analysis

For the sake of clarity, we will go in the order of the conservation alternatives shown in the list passed out by the MCWRA at the BMP Committee meeting on January 12, 1995.

Inclusion Mandated by Board of Supervisors

- Groundwater Charges- Included in Section 1) a-d of Agland's analysis on groundwater pricing. (The Section numbers refer to the outline shown in Part I of this memorandum.)

- Upper Pumping Limits- Included in Sections 2) and 3) on upper pumping limits.

- Drought Contingency Plan- Essentially a variation on Sections 2) and 3) on upper pumping limits, this alternative would be discussed in these sections as well as in the socio-economic section of the EIR.

Additional Options for Analysis

- No Project Scenario - Included and defined in EDAW's EIR. It includes the existing conservation activities and no new structural solution or demand reduction activities. This becomes the baseline for the analysis that would be done in essentially all of Agland's work.

- Tradable Groundwater Credits - Included in Section 4) of Agland's analysis on tradable groundwater withdrawal permits. This option would be combined with some sort of upper pumping limit. A preliminary opinion by legal experts on water suggests that there is a legal basis for this type of trading. We are submitting a memorandum to these lawyers for a more in-depth legal opinion.

- Growth Inhibitors (Urban and Agricultural) - This alternative would be discussed in the socio-economic study as part of any potential program of conservation measures. It could also be in essence part of the upper pumping limit.

- Educational Programs (Urban and Agricultural) - This alternative would be discussed in the socio-economic study as part of the potential program of conservation measures. It would support other conservation measures and might include an expansion of on-going educational efforts. It could also be looked at as part of the irrigation technology improvements, Section 5).

- Fallowing of Agricultural Lands - This alternative would be discussed in the socio-economic study as part of the potential program of conservation measures. It could include an analysis of potential benefits of fallowing some land in environmentally sensitive areas, such as riparian corridors.

- Allocation of Determined Basin Waters - This alternative is essentially a combination of upper pumping limits and tradable groundwater withdrawal permits. It would be included in Sections 2), 3), and 4).

- Economic Incentive/Disincentive Program - This is a specific way of implementing a conservation program using an incentive program. This would be studied under Section 1), groundwater pricing, and would also be looked at in the socio-economic analysis.

- Extraction Fee Economic Conservation - This is a type of groundwater pricing and would be looked at in Section 1c), under tiered groundwater pricing.

- Irrigation Efficiency - Included specifically in Section 5), irrigation technology improvements.

- Pumping Reduction Specific to Sub Areas - Included in Section 3), upper pumping limits by region.

- Existing and Adopted Conservation Activities - This measures would be discussed in the socio-economic study as part of the potential program of conservation measures and part of the no-action scenario baseline.

In conclusion, we believed that the outline our of analysis as shown in Section I of this memorandum essentially covers the points raised in the MCWRA "Options for Conversation Alternatives."

III. Usefulness of This Analysis

This economic analysis has been described as a tool for decision-makers. But just what does that mean practically. We believe that this report will help the BMP Committee and other policy makers understand the following:

1. The agricultural economy in the Salinas Valley and how it differs by sub-area. This will help in understanding how different parts of the Valley would be affected by different conservation alternatives.

2. The economic cost of different conservation alternatives. Which policy will be the most advantageous economically for the people of Monterey County? Which conservation policies are the most cost-efficient in achieving a given conservation goal?

3. The potential contribution of conservation measures to a solution to the water problems of the Salinas Valley. The usefulness of conservation measures needs to be judged in light of their potential costs. Knowing the cost of conservation helps make a decision about the type of infrastructure project that is needed.

4. A better knowledge of the costs of conservation measures for both the urban and the rural sectors, since the input-output model will provide a measure of economic impact for both.

We are about to begin the process of data collection, and would like your guidance on the date by which the final set of alternatives will be approved for analysis.

Appendix 2: Production Database

Table 2-1
Crop Acreage Assumptions Used in Model
By Season and Area

Acreage By Season	Area	Broccoli	Cauliflower	Celery	Head Let.	Leaf Let.	Strawberries	Grapes
Winter -	Pressure	1,306	2,019	0	0	0	0	0
	Eastside	3,424	456	0	0	0	0	0
	Forebay	2,986	764	0	0	0	0	0
	Upper Valley	2,318	514	0	0	0	0	0
Spring -	Pressure	3,918	6,057	0	15,289	6,466	375	0
	Eastside	10,272	1,369	0	5,992	2,534	1,209	0
	Forebay	8,959	2,291	0	7,208	3,049	0	0
	Upper Valley	6,955	1,543	0	1,466	620	0	0
Summer -	Pressure	5,224	8,076	4,065	30,578	12,932	749	0
	Eastside	13,696	1,825	964	11,984	5,068	2,418	0
	Forebay	11,945	3,055	2,088	14,417	6,097	0	0
	Upper Valley	9,273	2,057	731	2,932	1,240	0	0
Fall -	Pressure	2,612	4,038	1,742	15,289	6,466	375	1,264
	Eastside	6,848	912	413	5,992	2,534	1,209	4,226
	Forebay	5,972	1,528	895	7,208	3,049	0	22,954
	Upper Valley	4,637	1,029	313	1,466	620	0	27,422

Sources: Department of Water Resources and Monterey County Annual Crop Report, 1994
(Adjusted for the requirements of modeling - See text for explanation)

Table 2-2
Model Crop Prices

Price	Broccoli ($/Carton)	Cauliflower ($/Carton)	Celery ($/Carton)	Head Let ($/Carton)	Leaf Let ($/Carton)	Strawberries ($/Slide)	Grapes ($/Ton)
Winter (Dec-Feb)	6.22	7.01	--	--	--	--	--
Spring (Mar-May)	5.82	6.77	--	5.84	5.84	6.61	--
Summer (Jun-Aug)	5.78	6.75	6.81	5.94	5.94	6.31	--
Fall(Sep-Nov)	6.52	6.93	6.96	6.32	6.37	6.45	920.00
Harvest Cost	3.75	4.50	4.25	3.65	3.76	3.13	122.00

Source: Price data are averages over a 12 year period (1982-1994) taken from a variety of sources including Monterey County Agricultural Crop Reports; California Fresh Fruit and Vegtable Shipments, CDFA and USDA; Agriculture Prices, US Agriculture Standards Board. Harvest data from crop budgets for Monterey County.

Table 2-3
Applied Water
(Acre/Inches)

Season - Region	Broccoli	Cauliflower	Celery	Head Let	Leaf Let	Strawberries	Grapes
Winter-Pressure	11.39	13.62	14.99	--	--	--	--
Eastside	12.11	14.47	15.89	--	--	--	--
Forebay	14.14	16.88	20.11	--	--	--	--
Upper Valley	13.18	15.64	24.36	--	--	--	--
Spring-Pressure	11.39	13.62	20.20	7.42	7.42	36.00	--
Eastside	12.11	14.47	21.57	7.72	7.72	36.00	--
Forebay	14.14	16.88	25.08	9.17	9.17	--	--
Upper Valley	13.18	15.64	23.40	9.17	9.17	--	--
Summer-Pressure	12.41	14.82	17.35	10.80	10.80	36.00	--
Eastside	13.35	16.19	18.80	11.83	11.83	36.00	--
Forebay	15.47	19.95	22.13	15.54	15.54	--	--
Upper Valley	13.96	19.27	20.80	15.54	15.54	--	--
Fall-Pressure	12.41	13.23	21.21	10.80	10.80	36.00	28.41
Eastside	13.35	14.27	23.00	11.83	11.83	36.00	30.70
Forebay	15.47	18.79	29.94	15.54	15.54	--	38.25
Upper Valley	13.96	21.44	32.63	15.54	15.54	--	39.50

Source: U.S. Bureau of Reclamation, MCWRA Crop Calender and Net Irrigation Water Use Model, Task 1.06.5

Table 2-4
Pumping Cost Assumptions

Pumping Cost	South Valley	North Valley
Acre-Foot	0.25	0.25
Acre-Inch	0.02	0.02

Pumping Depth	South Valley	North Valley
	200	300

Table 2-5
Page 1
Model Crop Budgets

Harvest Season:	Winter			
Region:	**Pressure**	**Pressure**	**Eastside**	**Eastside**
Crop:	Broccoli	Cauliflower	Broccoli	Cauliflower
Units	Cartons*	Cartons*	Cartons	Cartons*
Yield (Units/Acre)	673.33	805.00	638.33	787.50
Labor/Prep ($/Acre)	599.98	903.60	613.88	931.10
Water "	71.19	85.13	75.69	90.44
Fertilizer "	170.54	143.57	168.23	143.57
Pest./Herb. "	83.14	93.64	78.11	93.64
Rent "	435.42	421.63	360.42	331.63
G&A "	62.22	53.38	58.61	53.38
Harvest "	2,525.00	3,622.50	2,393.75	3,543.75
Total Cost ($/Acre)	3,947.50	5,323.43	3,748.69	5,187.50
Price ($/Unit)	6.22	7.01	6.22	7.01
Revenue ($/Acre)	4,188.13	5,643.05	3,970.43	5,520.38
Net Revenue($/Acre)	240.64	319.62	221.74	332.88
Applied Water(In/Ac)	11.39	13.62	12.11	14.47
Acreage (Acres)	1,306.00	2,018.97	3,424.00	456.18
Net Rev. per AF ($/AF)	253.52	281.60	219.73	276.06
Gross Revenue ($'000)	5,469.69	11,393.15	13,594.76	2,518.28
Total Water Use (AF)	1,239.61	2,291.53	3,455.39	550.08
Seawater Int.('000 AF)	0.21	0.38	0.58	0.09

Harvest Season:	Winter			
Region:	**Forebay**	**Forebay**	**Upper Valley**	**Upper Valley**
Crop:	Broccoli	Cauliflower	Broccoli	Cauliflower
Units	Cartons*	Cartons*	Cartons	Cartons
Yield (Units/Acre)	605.83	749.92	581.33	725.00
Labor/Prep ($/Acre)	644.04	927.36	631.86	945.75
Water "	58.92	70.33	54.92	65.17
Fertilizer "	170.90	160.03	197.93	161.50
Pest./Herb. "	83.11	95.02	99.41	99.35
Rent "	274.04	260.83	192.92	190.00
G&A "	58.25	60.88	68.63	63.75
Harvest "	2,271.88	3,374.63	2,180.00	3,262.50
Total Cost ($/Acre)	3,561.14	4,949.07	3,425.66	4,788.02
Price ($/Unit)	6.22	7.01	6.22	7.01
Revenue ($/Acre)	3,768.28	5,256.92	3,615.89	5,082.25
Net Revenue($/Acre)	207.14	307.84	190.24	294.23
Applied Water(In/Ac)	14.14	16.88	13.18	15.64
Acreage (Acres)	2,986.22	763.79	2,318.28	514.35
Net Rev. per AF ($/AF)	175.79	218.85	173.20	225.75
Gross Revenue ($'000)	11,252.93	4,015.18	8,382.65	2,614.07
Total Water Use (AF)	3,518.76	1,074.40	2,546.24	670.37
Seawater Int.('000 AF)	0.04	0.01	0.03	0.01

* Based on data from the Upper Valley and the Eastside, same season.

Table 2-5
Page 2
Model Crop Budgets

Harvest Season:	Spring				
Region:	Pressure	Pressure	Pressure	Pressure	Pressure
Crop:	Broccoli	Cauliflower	Head Let	Leaf Let	Strawberries
Units	Cartons*	Cartons**	Cartons**	Cartons	Slide
Yield (Units/Acre)	741.50	880.00	850.00	890.28	5,000.00
Labor/Prep ($/Acre)	591.94	945.89	645.96	698.92	4,474.09
Water "	71.19	85.13	46.38	46.38	225.00
Fertilizer "	174.33	143.57	130.12	118.47	520.00
Pest./Herb. "	74.62	81.49	239.51	227.38	2,372.15
Rent "	435.42	421.63	445.50	438.44	1,200.00
G&A "	57.22	53.38	53.38	51.42	5,164.06
Harvest "	2,780.63	3,960.00	3,102.50	3,347.44	15,650.00
Total Cost ($/Acre)	4,185.34	5,691.07	4,663.33	4,928.45	29,605.30
Price ($/Unit)	5.82	6.77	5.84	5.84	6.61
Revenue ($/Acre)	4,315.53	5,957.60	4,964.00	5,199.22	33,030.00
Net Revenue($/Acre)	130.19	266.53	300.67	270.77	3,424.70
Applied Water(In/Ac)	11.39	13.62	7.42	7.42	36.00
Acreage (Acres)	3,917.99	6,056.91	15,289.18	6,465.99	374.73
Net Rev. per AF ($/AF)	137.16	234.83	486.26	437.90	1,141.57
Gross Revenue ($'000)	16,908.21	36,084.65	75,895.50	33,618.12	12,377.28
Total Water Use (AF)	3,718.83	6,874.59	9,453.81	3,998.14	1,124.18
Seawater Int.('000 AF)	0.62	1.15	1.59	0.67	0.19

* Based on data from the Eastside, same season.
** Proportionate to data from the Forebay, in the Fall season.

Harvest Season:	Spring				
Region:	Eastside	Eastside	Eastside	Eastside	Eastside
Crop:	Broccoli	Cauliflower	Head Let	Leaf Let	Strawberries
Units	Cartons	Cartons*	Cartons*	Cartons	Slide
Yield (Units/Acre)	706.50	862.50	837.50	865.28	5,000.00
Labor/Prep ($/Acre)	605.84	973.39	645.96	710.12	4,474.09
Water "	75.69	90.44	48.25	48.25	225.00
Fertilizer "	172.02	143.57	165.12	121.89	520.00
Pest./Herb. "	69.59	81.49	239.51	231.12	2,372.15
Rent "	360.42	331.63	370.50	363.44	1,200.00
G&A "	53.61	53.38	53.38	51.26	5,164.06
Harvest "	2,649.38	3,881.25	3,056.88	3,253.44	15,650.00
Total Cost ($/Acre)	3,986.54	5,555.13	4,579.58	4,779.54	29,605.30
Price ($/Unit)	5.82	6.77	5.84	5.84	6.61
Revenue ($/Acre)	4,111.83	5,839.13	4,891.00	5,053.22	33,030.00
Net Revenue($/Acre)	125.29	283.99	311.42	273.69	3,424.70
Applied Water(In/Ac)	12.11	14.47	7.72	7.72	36.00
Acreage (Acres)	10,272.00	1,368.54	5,991.90	2,534.05	1,208.94
Net Rev. per AF ($/AF)	124.15	235.52	484.07	425.42	1,141.57
Gross Revenue ($'000)	42,236.70	7,991.08	29,306.40	12,805.13	39,931.21
Total Water Use (AF)	10,366.16	1,650.23	3,854.79	1,630.24	3,626.81
Seawater Int.('000 AF)	1.74	0.28	0.65	0.27	0.61

* Based on data from the Pressure area, same season.

Table 2-5

Page 3

Model Crop Budgets

Harvest Season:	Spring			
Region:	Forebay	Forebay	Forebay	Forebay
Crop:	Broccoli	Cauliflower	Head Let	Leaf Let
Units	Cartons*	Cartons*	Cartons*	Cartons
Yield (Units/Acre)	674.00	824.92	801.93	838.42
Labor/Prep ($/Acre)	636.00	969.65	671.59	727.71
Water "	58.92	70.33	38.21	38.21
Fertilizer "	174.69	160.03	166.38	135.27
Pest./Herb. "	74.59	82.87	249.57	237.26
Rent "	274.04	260.83	270.55	275.09
G&A "	53.25	60.88	53.38	51.42
Harvest "	2,527.50	3,712.13	2,927.04	3,152.46
Total Cost ($/Acre)	3,798.99	5,316.71	4,376.72	4,617.42
Price ($/Unit)	5.82	6.77	5.84	5.84
Revenue ($/Acre)	3,922.68	5,584.69	4,683.26	4,896.38
Net Revenue($/Acre)	123.69	267.98	306.55	278.96
Applied Water(In/Ac)	14.14	16.88	9.17	9.17
Acreage (Acres)	8,958.67	2,291.37	7,208.50	3,048.56
Net Rev. per AF ($/AF)	104.97	190.50	401.15	365.05
Gross Revenue ($'000)	35,141.98	12,796.59	33,759.28	14,926.92
Total Water Use (AF)	10,556.29	3,223.20	5,508.49	2,329.61
Seawater Int.('000 AF)	0.13	0.04	0.07	0.03

* Based on data from the Upper Valley

Harvest Season:	Spring			
Region:	Upper Valley	Upper Valley	Upper Valley	Upper Valley
Crop:	Broccoli	Cauliflower	Head Let	Leaf Let
Units	Cartons	Cartons	Cartons	Cartons
Yield (Units/Acre)	649.50	800.00	775.00	815.28
Labor/Prep ($/Acre)	623.82	988.04	679.81	725.38
Water "	54.92	65.17	38.21	38.21
Fertilizer "	201.72	161.50	178.50	145.28
Pest./Herb. "	90.88	87.20	248.33	252.87
Rent "	192.92	190.00	190.00	192.19
G&A "	63.63	63.75	63.75	61.79
Harvest "	2,435.63	3,600.00	2,828.75	3,065.44
Total Cost ($/Acre)	3,663.50	5,155.65	4,227.35	4,481.17
Price ($/Unit)	5.82	6.77	5.84	5.84
Revenue ($/Acre)	3,780.09	5,416.00	4,526.00	4,761.22
Net Revenue($/Acre)	116.59	260.35	298.65	280.05
Applied Water(In/Ac)	13.18	15.64	9.17	9.17
Acreage (Acres)	6,954.84	1,543.06	1,465.90	619.95
Net Rev. per AF ($/AF)	106.15	199.75	390.81	366.48
Gross Revenue ($'000)	26,289.91	8,357.22	6,634.67	2,951.71
Total Water Use (AF)	7,638.73	2,011.12	1,120.19	473.74
Seawater Int.('000 AF)	0.09	0.02	0.01	0.01

Table 2-5
Page 4
Model Crop Budgets

Harvest Season:	Summer					
Region:	Pressure	Pressure	Pressure	Pressure	Pressure	Pressure
Crop:	Broccoli	Cauliflower	Celery	Head Let	Leaf Let	Strawberries
Units	Cartons	Cartons	Cartons*	Cartons	Cartons	Slide
Yield (Units/Acre)	765.00	900.00	1,279.79	857.36	869.00	5,000.00
Labor/Prep ($/Acre)	603.47	916.51	1,777.15	655.33	698.23	4,474.09
Water "	77.56	92.63	108.44	67.50	67.50	225.00
Fertilizer "	160.03	113.43	230.22	129.74	119.14	520.00
Pest./Herb. "	91.31	97.07	481.85	276.32	250.21	2,372.15
Rent "	538.06	527.08	509.95	556.94	549.68	1,200.00
G&A "	56.43	58.13	55.44	55.25	55.14	5,164.06
Harvest "	2,868.75	4,050.00	5,439.09	3,129.35	3,267.44	15,650.00
Total Cost ($/Acre)	4,395.63	5,854.84	8,602.14	4,870.42	5,007.33	29,605.30
Price ($/Unit)	5.78	6.75	6.81	5.94	5.94	6.31
Revenue ($/Acre)	4,421.70	6,075.00	8,715.34	5,092.70	5,161.86	31,530.00
Net Revenue($/Acre)	26.07	220.16	113.20	222.28	154.53	1,924.70
Applied Water(In/Ac)	12.41	14.82	17.35	10.80	10.80	36.00
Acreage (Acres)	5,223.99	8,075.88	4,065.18	30,578.36	12,931.98	749.46
Net Rev. per AF ($/AF)	25.21	178.26	78.30	246.98	171.70	641.57
Gross Revenue ($'000)	23,098.91	49,060.97	35,429.40	155,726.47	66,753.07	23,630.37
Total Water Use (AF)	5,402.47	9,973.71	5,877.57	27,520.53	11,638.78	2,248.37
Seawater Int.('000 AF)	0.91	1.67	0.99	4.62	1.95	0.38

* Proportionate to data from the Lower Valley, in the Fall.

Harvest Season:	Summer					
Region:	Eastside	Eastside	Eastside	Eastside	Eastside	Eastside
Crop:	Broccoli	Cauliflower	Celery	Head Let	Leaf Let	Strawberries
Units	Cartons	Cartons*	Cartons**	Cartons*	Cartons	Slide
Yield (Units/Acre)	730.00	882.50	1,279.79	844.86	844.00	5,000.00
Labor/Prep ($/Acre)	617.37	944.01	1,777.15	655.33	709.43	4,474.09
Water "	83.44	101.19	117.50	73.94	73.94	225.00
Fertilizer "	157.72	113.43	240.22	164.74	122.57	520.00
Pest./Herb. "	86.28	97.07	521.85	276.32	253.95	2,372.15
Rent "	463.06	437.08	449.95	481.94	474.68	1,200.00
G&A "	52.82	58.13	55.44	55.25	54.98	5,164.06
Harvest "	2,737.50	3,971.25	5,439.09	3,083.73	3,173.44	15,650.00
Total Cost ($/Acre)	4,198.20	5,722.16	8,601.20	4,791.23	4,862.98	29,605.30
Price ($/Unit)	5.78	6.75	6.81	5.94	5.94	6.31
Revenue ($/Acre)	4,219.40	5,956.88	8,715.34	5,018.45	5,013.36	31,530.00
Net Revenue($/Acre)	21.20	234.72	114.14	227.22	150.38	1,924.70
Applied Water(In/Ac)	13.35	16.19	18.80	11.83	11.83	36.00
Acreage (Acres)	13,695.99	1,824.72	964.48	11,983.81	5,068.11	2,417.88
Net Rev. per AF ($/AF)	19.06	173.97	72.86	230.48	152.54	641.57
Gross Revenue ($'000)	57,788.87	10,869.63	8,405.76	60,140.16	25,408.24	76,235.61
Total Water Use (AF)	15,236.79	2,461.85	1,511.02	11,814.04	4,996.31	7,253.63
Seawater Int.('000 AF)	2.56	0.41	0.25	1.98	0.84	1.22

* Based on data from the Pressure area, same season.

** Proportionate to data from the Lower Valley, in the Fall.

Table 2-5
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Model Crop Budgets

Harvest Season:	Summer				
Region:	Forebay	Forebay	Forebay	Forebay	Forebay
Crop:	Broccoli	Cauliflower	Celery	Head Let	Leaf Let
Units	Cartons	Cartons	Cartons	Cartons	Cartons
Yield (Units/Acre)	697.50	844.92	1,256.91	809.29	817.14
Labor/Prep ($/Acre)	647.53	940.27	1,855.07	680.97	727.02
Water "	64.46	83.13	92.21	64.75	64.75
Fertilizer "	160.39	129.89	251.61	166.00	135.94
Pest./Herb. "	91.28	98.45	464.06	286.38	260.09
Rent "	376.69	366.29	378.32	381.99	386.32
G&A "	52.46	65.63	54.00	55.25	55.14
Harvest "	2,615.63	3,802.13	5,341.87	2,953.89	3,072.46
Total Cost ($/Acre)	4,008.44	5,485.78	8,437.14	4,589.22	4,701.72
Price ($/Unit)	5.78	6.75	6.81	5.94	5.94
Revenue ($/Acre)	4,031.55	5,703.19	8,559.56	4,807.16	4,853.83
Net Revenue($/Acre)	23.11	217.41	122.42	217.93	152.11
Applied Water(In/Ac)	15.47	19.95	22.13	15.54	15.54
Acreage (Acres)	11,944.89	3,055.16	2,087.80	14,416.99	6,097.13
Net Rev. per AF ($/AF)	17.93	130.77	66.38	168.29	117.46
Gross Revenue ($'000)	48,156.41	17,424.17	17,870.67	69,304.74	29,594.42
Total Water Use (AF	15,398.95	5,079.21	3,850.25	18,670.00	7,895.78
Seawater Int.('000 AF)	0.19	0.06	0.05	0.23	0.10

Harvest Season:	Summer				
Region:	Upper Valley	Upper Valley	Upper Valley	Upper Valley	Upper Valley
Crop:	Broccoli	Cauliflower	Celery	Head Let	Leaf Let
Units	Cartons	Cartons	Cartons	Cartons	Cartons
Yield (Units/Acre)	673.00	820.00	1,255.79	782.36	794.00
Labor/Prep ($/Acre)	635.35	958.66	1,840.52	689.19	724.68
Water "	58.17	80.29	86.67	64.75	64.75
Fertilizer "	187.42	131.36	267.53	178.12	145.96
Pest./Herb. "	107.58	102.78	542.44	285.14	275.69
Rent "	295.56	295.46	295.82	301.44	303.43
G&A "	62.84	68.50	60.00	65.63	65.51
Harvest "	2,523.75	3,690.00	5,337.09	2,855.60	2,985.44
Total Cost ($/Acre)	3,870.66	5,327.05	8,430.08	4,439.86	4,565.46
Price ($/Unit)	5.78	6.75	6.81	5.94	5.94
Revenue ($/Acre)	3,889.94	5,535.00	8,551.90	4,647.20	4,716.36
Net Revenue($/Acre)	19.28	207.95	121.83	207.34	150.90
Applied Water(In/Ac)	13.96	19.27	20.80	15.54	15.54
Acreage (Acres)	9,273.11	2,057.41	731.04	2,931.80	1,239.90
Net Rev. per AF ($/AF)	16.57	129.50	70.28	160.11	116.52
Gross Revenue ($'000)	36,071.86	11,387.79	6,251.78	13,624.68	5,847.80
Total Water Use (AF	10,787.72	3,303.86	1,267.14	3,796.68	1,605.67
Seawater Int.('000 AF)	0.13	0.04	0.02	0.05	0.02

Table 2-5
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Model Crop Budgets

Harvest Season:	Fall					
Region:	Pressure	Pressure	Pressure	Pressure	Pressure	Pressure
Crop:	Broccoli	Cauliflower	Celery	Head Let	Leaf Let	Strawberries
Units	Cartons	Cartons	Cartons*	Cartons	Cartons	Slide
Yield (Units/Acre)	665.00	836.67	1,256.64	773.17	782.10	5,000.00
Labor/Prep ($/Acre)	630.04	936.65	1,836.73	672.74	703.76	4,474.09
Water "	77.56	82.69	132.56	67.50	67.50	225.00
Fertilizer "	176.14	111.27	221.89	140.29	125.54	520.00
Pest./Herb. "	110.75	107.09	477.70	286.16	261.93	2,372.15
Rent "	530.92	517.54	476.15	528.80	509.15	1,200.00
G&A "	62.22	58.13	48.06	58.13	62.15	5,164.06
Harvest "	2,493.75	3,765.00	5,340.73	2,822.06	2,940.70	15,650.00
Total Cost ($/Acre)	4,081.38	5,578.36	8,533.82	4,575.67	4,670.72	29,605.30
Price ($/Unit)	6.52	6.93	6.96	6.32	6.37	6.45
Revenue ($/Acre)	4,335.80	5,798.10	8,746.23	4,886.41	4,981.98	32,250.00
Net Revenue($/Acre)	254.42	219.75	212.41	310.75	311.26	2,644.70
Applied Water(In/Ac)	12.41	13.23	21.21	10.80	10.80	36.00
Acreage (Acres)	2,611.99	4,037.94	1,742.22	15,289.18	6,465.99	374.73
Net Rev. per AF ($/AF)	246.02	199.32	120.18	345.28	345.84	881.57
Gross Revenue ($'000)	11,325.08	23,412.38	15,237.85	74,709.26	32,213.42	12,084.99
Total Water Use (AF)	2,701.24	4,451.83	3,079.37	13,760.26	5,819.39	1,124.18
Seawater Int.('000 AF)	0.45	0.75	0.52	2.31	0.98	0.19

* Based on data from the Eastside

** Proportional to data from the Pressure area, in the Summer.

Harvest Season:	Fall						
Region:	Eastside	Eastside	Eastside	Eastside	Eastside	Eastside	Eastside
Crop:	Broccoli	Cauliflower	Celery	Head Let	Leaf Let	Strawberries	Grapes
Units	Cartons	Cartons*	Cartons	Cartons*	Cartons	Slide	Tons
Yield (Units/Acre)	630.00	819.17	1,256.64	760.67	757.10	5,000.00	3.28
Labor/Prep ($/Acre)	643.94	964.15	1,836.73	672.74	714.96	4,474.09	816.79
Water "	83.44	89.19	143.75	73.94	73.94	225.00	191.88
Fertilizer "	173.83	111.27	231.89	175.29	128.96	520.00	23.12
Pest./Herb. "	105.71	107.09	517.70	286.16	265.67	2,372.15	208.08
Rent "	455.92	427.54	416.15	453.80	434.15	1,200.00	262.50
G&A "	58.61	58.13	48.06	58.13	61.99	5,164.06	322.25
Harvest "	2,362.50	3,686.25	5,340.73	2,776.43	2,846.70	15,650.00	399.55
Total Cost ($/Acre)	3,883.95	5,443.61	8,535.01	4,496.48	4,526.37	29,605.30	2,224.16
Price ($/Unit)	6.52	6.93	6.96	6.32	6.37	6.45	920.00
Revenue ($/Acre)	4,107.60	5,676.83	8,746.23	4,807.41	4,822.73	32,250.00	3,013.00
Net Revenue($/Acre)	223.65	233.22	211.22	310.94	296.36	2,644.70	788.84
Applied Water(In/Ac)	13.35	14.27	23.00	11.83	11.83	36.00	30.70
Acreage (Acres)	6,848.00	912.36	413.35	5,991.90	2,534.05	1,208.94	4,225.87
Net Rev. per AF ($/AF)	201.04	196.12	110.20	315.40	300.62	881.57	308.34
Gross Revenue ($'000)	28,128.83	5,179.31	3,615.24	28,805.56	12,221.05	38,988.24	12,732.55
Total Water Use (AF)	7,618.40	1,084.95	792.25	5,907.02	2,498.15	3,626.81	10,811.19
Seawater Int.('000 AF)	1.28	0.18	0.13	0.99	0.42	0.61	1.82

* Based on data from the Pressure area

** Proportional to data from the Eastside area, in the Summer.

Table 2-5
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Model Crop Budgets

Harvest Season:	Fall					
Region:	Forebay	Forebay	Forebay	Forebay	Forebay	Forebay
Crop:	Broccoli	Cauliflower	Celery	Head Let	Leaf Let	Grapes
Units	Cartons	Cartons	Cartons	Cartons	Cartons	Tons
Yield (Units/Acre)	597.50	781.58	1,233.77	725.10	730.24	3.63
Labor/Prep ($/Acre)	674.09	960.41	1,914.65	698.37	732.55	893.90
Water "	64.46	78.29	124.75	64.75	64.75	159.38
Fertilizer "	176.50	127.73	243.28	176.55	142.34	21.82
Pest./Herb. "	110.72	108.46	459.91	296.22	271.81	196.43
Rent "	369.54	356.75	344.52	353.85	345.79	281.25
G&A "	58.25	65.63	46.62	58.13	62.15	300.16
Harvest "	2,240.63	3,517.13	5,243.51	2,646.60	2,745.71	442.25
Total Cost ($/Acre)	3,694.19	5,214.39	8,377.24	4,294.47	4,365.11	2,295.18
Price ($/Unit)	6.52	6.93	6.96	6.32	6.37	920.00
Revenue ($/Acre)	3,895.70	5,416.37	8,587.02	4,582.60	4,651.65	3,335.00
Net Revenue($/Acre)	201.51	201.98	209.78	288.13	286.54	1,039.82
Applied Water(In/Ac)	15.47	18.79	29.94	15.54	15.54	38.25
Acreage (Acres)	5,972.44	1,527.58	894.77	7,208.50	3,048.56	22,953.68
Net Rev. per AF ($/AF)	156.31	128.99	84.08	222.50	221.27	326.22
Gross Revenue ($'000)	23,266.85	8,273.95	7,683.43	33,033.66	14,180.85	76,550.52
Total Water Use (AF	7,699.48	2,391.94	2,232 46	9,335.00	3,947.89	73,164.86
Seawater Int.('000 AF)	0.10	0.03	0.03	0.12	0.05	0.90

Harvest Season:	Fall					
Region:	Upper Valley	Upper Valley	Upper Valley	Upper Valley	Upper Valley	Upper Valley
Crop:	Broccoli	Cauliflower	Celery	Head Let	Leaf Let	Grapes
Units	Cartons	Cartons	Cartons	Cartons	Cartons	Tons
Yield (Units/Acre)	573.00	756.67	1,232.64	698.17	707.10	3.63
Labor/Prep ($/Acre)	661.92	978.80	1,900.10	706.59	730.21	893.90
Water "	58.17	89.33	135.96	64.75	64.75	164.58
Fertilizer "	203.53	129.20	259.20	188.67	152.35	21.82
Pest./Herb. "	127.01	112.80	538.29	294.98	287.42	196.43
Rent "	288.42	285.92	262.02	273.30	262.90	281.25
G&A "	68.63	68.50	52.62	68.50	72.53	300.16
Harvest "	2,148.75	3,405.00	5,238.73	2,548.31	2,658.70	442.25
Total Cost ($/Acre)	3,556.41	5,069.54	8,386.93	4,145.11	4,228.85	2,300.39
Price ($/Unit)	6.52	6.93	6.96	6.32	6.37	920.00
Revenue ($/Acre)	3,735.96	5,243.70	8,579.19	4,412.41	4,504.23	3,335.00
Net Revenue($/Acre)	179.55	174.16	192.26	267.31	275.37	1,034.61
Applied Water(In/Ac)	13.96	21.44	32.63	15.54	15.54	39.50
Acreage (Acres)	4,636.56	1,028.71	313.30	1,465.90	619.95	27,422.20
Net Rev. per AF ($/AF)	154.34	97.48	70.71	206.41	212.64	314.31
Gross Revenue ($'000)	17,321.99	5,394.23	2,687.89	6,468.16	2,792.39	91,453.04
Total Water Use (AF	5,393.86	1,837.96	851.92	1,898.34	802.83	90,264.74
Seawater Int.('000 AF)	0.07	0.02	0.01	0.02	0.01	1.12

Appendix 3: Hydrologic Database

Table 3-1

Results of the Hydrologic Statistical Analysis

Regression Statistics	
Multiple R	0.99213275
R Square	0.9843274
Adjusted R Square	0.97805836
Standard Error	1.34780553
Observations	8

Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regression	2	570.457101	285.228551	157.014054	3.0751E-05
Residual	5	9.08289873	1.81657975		
Total	7	579.54			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-21.9522363	2.06648679	-10.6229744	1.4345E-05	-27.264301	-16.6401716
North Valley Pumping	0.1678997	0.01290878	13.0066302	3.6967E-06	0.13471668	0.20108272
South Valley Pumping	0.01235759	0.01139327	1.08463925	0.3140183	-0.01692969	0.04164487
Ratio	13.5867717					

Source: Statistical analysis is based on results from the preliminary screening of alternatives completed by Montgomerey Watson and presented to the MCWRA staff.

Appendix 4: Economic Impacts

Table 4-1

Policy Summary By Region
50% Level of Reduction

No Action Alternative

Crop:	Pressure	Eastside	Forebay	Upper Valley	Total
Net Revenue (000)	33,004	29,231	39,419	33,913	135,567
Net Revenue per AF	270	290	224	249	253
Net Rev/AF Intrusion	18,425	19,810	207,914	230,856	37,623
Saltwater Int. (000)	1.79	1.48	0.19	0.15	3.60
Total Water Use (AF)	122,298	100,746	175,877	136,271	535,192
Acreage	127,577	83,345	104,465	65,136	380,523

Region-Specific Land Use Charge

Crop:	Pressure	Eastside	Forebay	Upper Valley	Total
Net Revenue (000)	17,622	20,242	39,419	33,913	111,196
Net Revenue per AF	159	267	224	249	223
Total Water Use (AF)	111,018	75,705	175,877	136,271	498,871
Acreage	118,288	60,467	104,465	65,136	348,355

Region-Specific Pumping Charge

Crop:	Pressure	Eastside	Forebay	Upper Valley	Total
Net Revenue (000)	18,653	18,425	39,419	33,913	110,410
Net Revenue per AF	173	234	224	249	221
Total Water Use (AF)	107,939	78,852	175,877	136,271	498,939
Acreage	116,545	63,957	104,465	65,136	350,103

Uniform Land Use Charge

Crop:	Pressure	Eastside	Forebay	Upper Valley	Total
Net Revenue (000)	17,622	20,243	27,595	26,812	92,272
Net Revenue per AF	159	255	189	230	204
Total Water Use (AF)	111,018	79,334	146,071	116,578	453,001
Acreage	118,288	64,062	81,473	48,177	312,000

Uniform Pumping Charge

Crop:	Pressure	Eastside	Forebay	Upper Valley	Total
Net Revenue (000)	19,085	18,758	20,351	18,934	77,128
Net Revenue per AF	177	225	150	169	176
Total Water Use (AF)	107,970	83,206	135,943	112,282	439,401
Acreage	116,563	68,271	74,481	45,595	304,911

Upper Pumping Limit

Crop:	Pressure	Eastside	Forebay	Upper Valley	Total
Net Revenue (000)	28,148	24,930	33,408	28,741	115,228
Net Revenue per AF	270	290	224	249	253
Total Water Use (AF)	104,306	85,924	149,057	115,491	454,779
Acreage	108,808	71,083	88,535	55,204	323,629

Region-Specific Upper Pumping Limit

Crop:	Pressure	Eastside	Forebay	Upper Valley	Total
Net Revenue (000)	27,627	24,469	39,419	33,913	125,428
Net Revenue per AF	270	290	224	249	251
Total Water Use (AF)	102,376	84,334	175,877	136,271	498,858
Acreage	106,794	69,768	104,465	65,136	346,163

Table 4-2

Policy Summary By Crop
50% Level of Reduction

No Action Alternative

Crop:	Broccoli	Cauliflower	Celery	Grapes	Head Let	Leaf Let	Strawberries	Total
Net Revenue (000)	10,963	9,089	1,620	55,572	31,463	11,151	15,708	135,567
Net Revenue per AF	97	186	83	319	279	234	827	253
Net Rev/AF Intrusion	13,755	20,160	9,324	166,125	28,536	23,915	56,435	37,623
Saltwater Int. (000)	0.80	0.45	0.17	0.33	1.10	0.47	0.28	3.60
Total Water Use (AF)	113,279	48,931	19,462	174,241	112,639	47,637	19,004	535,192
Acreage	100,345	37,533	11,212	54,602	119,822	50,674	6,335	380,523

Region-Specific Land Use Charge

Crop:	Broccoli	Cauliflower	Celery	Grapes	Head Let	Leaf Let	Strawberries	Total
Net Revenue (000)	6,986	5,995	781	55,044	20,823	6,651	14,916	111,196
Net Revenue per AF	83	123	65	316	185	140	785	223
Total Water Use (AF)	84,347	48,931	12,073	174,241	112,639	47,637	19,004	498,871
Acreage	73,207	37,533	6,182	54,602	119,822	50,674	6,335	348,355

Region-Specific Pumping Charge

Crop:	Broccoli	Cauliflower	Celery	Grapes	Head Let	Leaf Let	Strawberries	Total
Net Revenue (000)	6,927	5,450	593	54,232	22,497	7,359	13,352	110,410
Net Revenue per AF	78	111	72	311	200	154	703	221
Total Water Use (AF)	88,286	48,931	8,202	174,241	112,639	47,637	19,004	498,939
Acreage	77,111	37,533	4,027	54,602	119,822	50,674	6,335	350,103

Uniform Land Use Charge

Crop:	Broccoli	Cauliflower	Celery	Grapes	Head Let	Leaf Let	Strawberries	Total
Net Revenue (000)	2,624	4,397	285	48,747	16,486	4,817	14,916	92,272
Net Revenue per AF	60	90	41	280	146	101	785	204
Total Water Use (AF)	43,593	48,931	6,956	174,241	112,639	47,637	19,004	453,001
Acreage	39,671	37,533	3,364	54,602	119,822	50,674	6,335	312,000

Uniform Pumping Charge

Crop:	Broccoli	Cauliflower	Celery	Grapes	Head Let	Leaf Let	Strawberries	Total
Net Revenue (000)	2,371	3,258	0	34,663	17,947	5,460	13,428	77,128
Net Revenue per AF	49	69	0	199	159	143	707	176
Total Water Use (AF)	48,258	47,093	31	174,241	112,639	38,135	19,004	439,401
Acreage	44,293	36,504	17	54,602	119,822	43,337	6,335	304,911

Upper Pumping Limit

Crop:	Broccoli	Cauliflower	Celery	Grapes	Head Let	Leaf Let	Strawberries	Total
Net Revenue (000)	9,321	7,735	1,379	47,116	26,787	9,494	13,397	115,228
Net Revenue per AF	97	186	83	319	279	234	827	253
Total Water Use (AF)	96,272	41,627	16,555	147,729	95,851	40,537	16,208	454,779
Acreage	85,297	31,942	9,541	46,298	102,007	43,140	5,403	323,629

Region-Specific Upper Pumping Limit

Crop:	Broccoli	Cauliflower	Celery	Grapes	Head Let	Leaf Let	Strawberries	Total
Net Revenue (000)	10,068	8,094	1,453	55,029	27,782	9,853	13,149	125,428
Net Revenue per AF	96	183	82	319	275	231	827	251
Total Water Use (AF)	105,176	44,151	17,628	172,480	100,860	42,655	15,908	498,858
Acreage	92,640	33,501	10,042	53,913	105,955	44,810	5,303	346,163

Table 4-3

Page 1

Summary of Policy Results

50% Level of Reduction

No Action Alternative

Region: Crop:	Pressure Broccoli	Pressure Cauliflower	Pressure Celery	Pressure Head Let	Pressure Leaf Let	Pressure Strawberries
Net Revenue (000)	1,625	4,925	830	16,145	5,762	3,717
Net Revenue per AF	124	209	93	318	269	827
Net Rev/AF Intrusion	741	1,243	552	1,895	1,599	4,923
Saltwater Int. (000)	0.65	1.17	0.44	2.52	1.06	0.22
Total Water Use (AF)	13,062	23,592	8,957	50,735	21,456	4,497
Acreage	13,060	20,190	5,807	61,157	25,864	1,499

Region: Crop:	Eastside Broccoli	Eastside Cauliflower	Eastside Celery	Eastside Grapes	Eastside Head Let	Eastside Leaf Let	Eastside Strawberries
Net Revenue (000)	3,868	1,182	197	3,334	6,452	2,207	11,991
Net Revenue per AF	105	206	86	308	299	242	827
Net Rev/AF Intrusion	628	1,225	510	1,836	1,781	1,440	4,923
Saltwater Int. (000)	1.82	0.28	0.11	0.54	1.07	0.45	0.72
Total Water Use (AF)	36,677	5,747	2,303	10,811	21,576	9,125	14,507
Acreage	34,240	4,562	1,378	4,226	23,968	10,136	4,836

Region: Crop:	Forebay Broccoli	Forebay Cauliflower	Forebay Celery	Forebay Grapes	Forebay Head Let	Forebay Leaf Let
Net Revenue (000)	3,206	1,822	443	23,868	7,429	2,651
Net Revenue per AF	86	155	73	326	222	187
Net Rev/AF Intrusion	6,980	12,528	5,898	26,398	17,937	15,138
Saltwater Int. (000)	0.14	0.04	0.02	0.27	0.12	0.05
Total Water Use (AF)	37,173	11,769	6,083	73,165	33,513	14,173
Acreage	29,862	7,638	2,983	22,954	28,834	12,194

Region: Crop:	Upper Valley Broccoli	Upper Valley Cauliflower	Upper Valley Celery	Upper Valley Grapes	Upper Valley Head Let	Upper Valley Leaf Let
Net Revenue (000)	2,263	1,160	149	28,371	1,438	531
Net Revenue per AF	86	148	70	314	211	184
Net Rev/AF Intrusion	6,946	11,999	5,701	25,435	17,069	14,921
Saltwater Int. (000)	0.10	0.03	0.01	0.33	0.02	0.01
Total Water Use (AF)	26,367	7,823	2,119	90,265	6,815	2,882
Acreage	23,183	5,144	1,044	27,422	5,864	2,480

Table 4-3

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Summary of Policy Results

50% Level of Reduction

Region-Specific Pumping Charge

Region:	Pressure	Pressure	Pressure	Pressure	Pressure	Pressure
Crop:	Broccoli	Cauliflower	Celery	Head Let	Leaf Let	Strawberries
Net Revenue (000)	539	2,000	0	9,854	3,101	3,159
Net Revenue per AF	70	85	0	194	145	703
Total Water Use (AF)	7,660	23,592	0	50,735	21,456	4,497
Acreage	7,836	20,190	0	61,157	25,864	1,499

Region:	Eastside	Eastside	Eastside	Eastside	Eastside	Eastside	Eastside
Crop:	Broccoli	Cauliflower	Celery	Grapes	Head Let	Leaf Let	Strawberries
Net Revenue (000)	919	469	0	1,993	3,777	1,075	10,192
Net Revenue per AF	54	82	0	184	175	118	703
Total Water Use (AF)	17,086	5,747	0	10,811	21,576	9,125	14,507
Acreage	16,230	4,562	0	4,226	23,968	10,136	4,836

Region:	Forebay	Forebay	Forebay	Forebay	Forebay	Forebay
Crop:	Broccoli	Cauliflower	Celery	Grapes	Head Let	Leaf Let
Net Revenue (000)	3,206	1,822	443	23,868	7,429	2,651
Net Revenue per AF	86	155	73	326	222	187
Total Water Use (AF)	37,173	11,769	6,083	73,165	33,513	14,173
Acreage	29,862	7,638	2,983	22,954	28,834	12,194

Region:	Upper Valley	Upper Valley	Upper Valley	Upper Valley	Upper Valley	Upper Valley
Crop:	Broccoli	Cauliflower	Celery	Grapes	Head Let	Leaf Let
Net Revenue (000)	2,263	1,160	149	28,371	1,438	531
Net Revenue per AF	86	148	70	314	211	184
Total Water Use (AF)	26,367	7,823	2,119	90,265	6,815	2,882
Acreage	23,183	5,144	1,044	27,422	5,864	2,480

Table 4-3
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Summary of Policy Results
50% Level of Reduction

Region-Specific Land Use Charge

Region: Crop:	Pressure Broccoli	Pressure Cauliflower	Pressure Celery	Pressure Head Let	Pressure Leaf Let	Pressure Strawberries
Net Revenue (000)	509	2,401	152	8,500	2,529	3,529
Net Revenue per AF	67	102	49	168	118	785
Total Water Use (AF)	7,660	23,592	3,079	50,735	21,456	4,497
Acreage	7,836	20,190	1,742	61,157	25,864	1,499

Region: Crop:	Eastside Broccoli	Eastside Cauliflower	Eastside Celery	Eastside Grapes	Eastside Head Let	Eastside Leaf Let	Eastside Strawberries
Net Revenue (000)	1,007	611	36	2,805	3,456	940	11,387
Net Revenue per AF	77	106	45	259	160	103	785
Total Water Use (AF)	13,147	5,747	792	10,811	21,576	9,125	14,507
Acreage	12,326	4,562	413	4,226	23,968	10,136	4,836

Region: Crop:	Forebay Broccoli	Forebay Cauliflower	Forebay Celery	Forebay Grapes	Forebay Head Let	Forebay Leaf Let
Net Revenue (000)	3,206	1,822	443	23,868	7,429	2,651
Net Revenue per AF	86	155	73	326	222	187
Total Water Use (AF)	37,173	11,769	6,083	73,165	33,513	14,173
Acreage	29,862	7,638	2,983	22,954	28,834	12,194

Region: Crop:	Upper Valley Broccoli	Upper Valley Cauliflower	Upper Valley Celery	Upper Valley Grapes	Upper Valley Head Let	Upper Valley Leaf Let
Net Revenue (000)	2,263	1,160	149	28,371	1,438	531
Net Revenue per AF	86	148	70	314	211	184
Total Water Use (AF)	26,367	7,823	2,119	90,265	6,815	2,882
Acreage	23,183	5,144	1,044	27,422	5,864	2,480

Table 4-3

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Summary of Policy Results

50% Level of Reduction

Region-Specific Upper Pumping Limit

Region: / Crop:	Pressure Broccoli	Pressure Cauliflower	Pressure Celery	Pressure Head Let	Pressure Leaf Let	Pressure Strawberries
Net Revenue (000)	1,360	4,123	695	13,515	4,823	3,111
Net Revenue per AF	124	209	93	318	269	827
Total Water Use (AF)	10,934	19,749	7,498	42,470	17,961	3,764
Acreage	10,932	16,901	4,861	51,194	21,651	1,255

Region: / Crop:	Eastside Broccoli	Eastside Cauliflower	Eastside Celery	Eastside Grapes	Eastside Head Let	Eastside Leaf Let	Eastside Strawberries
Net Revenue (000)	3,238	989	165	2,790	5,401	1,847	10,038
Net Revenue per AF	105	206	86	308	299	242	827
Total Water Use (AF)	30,702	4,811	1,928	9,050	18,061	7,638	12,144
Acreage	28,662	3,819	1,153	3,537	20,063	8,485	4,048

Region: / Crop:	Forebay Broccoli	Forebay Cauliflower	Forebay Celery	Forebay Grapes	Forebay Head Let	Forebay Leaf Let
Net Revenue (000)	3,206	1,822	443	23,868	7,429	2,651
Net Revenue per AF	86	155	73	326	222	187
Total Water Use (AF)	37,173	11,769	6,083	73,165	33,513	14,173
Acreage	29,862	7,638	2,983	22,954	28,834	12,194

Region: / Crop:	Upper Valley Broccoli	Upper Valley Cauliflower	Upper Valley Celery	Upper Valley Grapes	Upper Valley Head Let	Upper Valley Leaf Let
Net Revenue (000)	2,263	1,160	149	28,371	1,438	531
Net Revenue per AF	86	148	70	314	211	184
Total Water Use (AF)	26,367	7,823	2,119	90,265	6,815	2,882
Acreage	23,183	5,144	1,044	27,422	5,864	2,480

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Summary of Policy Results

50% Level of Reduction

Uniform Pumping Charge

Region: Crop:	Pressure Broccoli	Pressure Cauliflower	Pressure Celery	Pressure Head Let	Pressure Leaf Let	Pressure Strawberries
Net Revenue (000)	570	2,094	0	10,057	3,187	3,177
Net Revenue per AF	74	89	0	198	149	707
Total Water Use (AF)	7,660	23,592	31	50,735	21,456	4,497
Acreage	7,836	20,190	17	61,157	25,864	1,499

Region: Crop:	Eastside Broccoli	Eastside Cauliflower	Eastside Celery	Eastside Grapes	Eastside Head Let	Eastside Leaf Let	Eastside Strawberries
Net Revenue (000)	1,005	492	0	2,036	3,863	1,112	10,250
Net Revenue per AF	47	86	0	188	179	122	707
Total Water Use (AF)	21,440	5,747	0	10,811	21,576	9,125	14,507
Acreage	20,544	4,562	0	4,226	23,968	10,136	4,836

Region: Crop:	Forebay Broccoli	Forebay Cauliflower	Forebay Celery	Forebay Grapes	Forebay Head Let	Forebay Leaf Let
Net Revenue (000)	476	410	0	15,088	3,407	971
Net Revenue per AF	42	35	0	206	102	155
Total Water Use (AF)	11,218	11,769	0	73,165	33,513	6,278
Acreage	8,959	7,638	0	22,954	28,834	6,097

Region: Crop:	Upper Valley Broccoli	Upper Valley Cauliflower	Upper Valley Celery	Upper Valley Grapes	Upper Valley Head Let	Upper Valley Leaf Let
Net Revenue (000)	321	263	0	17,539	620	191
Net Revenue per AF	40	44	0	194	91	150
Total Water Use (AF)	7,940	5,985	0	90,265	6,815	1,277
Acreage	6,955	4,115	0	27,422	5,864	1,240

Table 4-3

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Summary of Policy Results

50% Level of Reduction

Uniform Land Use Charge

Region:	Pressure	Pressure	Pressure	Pressure	Pressure	Pressure
Crop:	Broccoli	Cauliflower	Celery	Head Let	Leaf Let	Strawberries
Net Revenue (000)	509	2,401	152	8,500	2,529	3,529
Net Revenue per AF	67	102	49	168	118	785
Total Water Use (AF)	7,660	23,592	3,079	50,735	21,456	4,497
Acreage	7,836	20,190	1,742	61,157	25,864	1,499

Region:	Eastside	Eastside	Eastside	Eastside	Eastside	Eastside	Eastside
Crop:	Broccoli	Cauliflower	Celery	Grapes	Head Let	Leaf Let	Strawberries
Net Revenue (000)	1,008	611	36	2,805	3,456	940	11,387
Net Revenue per AF	60	106	45	259	160	103	785
Total Water Use (AF)	16,775	5,747	792	10,811	21,576	9,125	14,507
Acreage	15,922	4,562	413	4,226	23,968	10,136	4,836

Region:	Forebay	Forebay	Forebay	Forebay	Forebay	Forebay
Crop:	Broccoli	Cauliflower	Celery	Grapes	Head Let	Leaf Let
Net Revenue (000)	702	867	76	20,998	3,824	1,127
Net Revenue per AF	63	74	34	287	114	80
Total Water Use (AF)	11,218	11,769	2,232	73,165	33,513	14,173
Acreage	8,959	7,638	895	22,954	28,834	12,194

Region:	Upper Valley	Upper Valley	Upper Valley	Upper Valley	Upper Valley	Upper Valley
Crop:	Broccoli	Cauliflower	Celery	Grapes	Head Let	Leaf Let
Net Revenue (000)	404	517	21	24,943	705	221
Net Revenue per AF	51	66	25	276	103	77
Total Water Use (AF)	7,940	7,823	852	90,265	6,815	2,882
Acreage	6,955	5,144	313	27,422	5,864	2,480

Table 4-3

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Summary of Policy Results

50% Level of Reduction

Upper Pumping Limit

Region: / Crop:	Pressure Broccoli	Pressure Cauliflower	Pressure Celery	Pressure Head Let	Pressure Leaf Let	Pressure Strawberries
Net Revenue (000)	1,386	4,200	708	13,770	4,914	3,170
Net Revenue per AF	124	209	93	318	269	827
Total Water Use (AF)	11,140	20,121	7,639	43,271	18,300	3,835
Acreage	11,139	17,219	4,953	52,159	22,059	1,278

Region: / Crop:	Eastside Broccoli	Eastside Cauliflower	Eastside Celery	Eastside Grapes	Eastside Head Let	Eastside Leaf Let	Eastside Strawberries
Net Revenue (000)	3,299	1,008	168	2,843	5,503	1,882	10,227
Net Revenue per AF	105	206	86	308	299	242	827
Total Water Use (AF)	31,281	4,902	1,964	9,221	18,402	7,782	12,373
Acreage	29,203	3,891	1,175	3,604	20,442	8,645	4,124

Region: / Crop:	Forebay Broccoli	Forebay Cauliflower	Forebay Celery	Forebay Grapes	Forebay Head Let	Forebay Leaf Let
Net Revenue (000)	2,717	1,544	376	20,228	6,296	2,247
Net Revenue per AF	86	155	73	326	222	187
Total Water Use (AF)	31,505	9,974	5,155	62,008	28,403	12,012
Acreage	25,309	6,473	2,528	19,453	24,437	10,335

Region: / Crop:	Upper Valley Broccoli	Upper Valley Cauliflower	Upper Valley Celery	Upper Valley Grapes	Upper Valley Head Let	Upper Valley Leaf Let
Net Revenue (000)	1,918	983	127	24,045	1,218	450
Net Revenue per AF	86	148	70	314	211	184
Total Water Use (AF)	22,346	6,630	1,796	76,500	5,776	2,443
Acreage	19,648	4,359	885	23,241	4,969	2,102

Appendix 5: Impact of Conservation Options Upon Sales, Employee Compensation, and Employment

Table 5.1 Impact of Conservation Options Upon Sales, Employee Compensation and Employment

Policy Options	Percent Reduction of Seawater Intrusion		
	10%	25%	50%
1. Region Specific Pumping Charge			
mpact on Agriculture Sector			
Reduction in Farm Sales ($000) (1)	27,739	325,408	492,080
Reduction in Employee Compensation ($000) (2)	2,155	25,284	38,235
Reduction in Farm Employment	305	3,574	5,404
mpact on County			
Direct and Indirect Impact on Sales ($000)	34,743	454,500	691,347
Direct, Indirect and Induced Impact on Sales ($000)	51,930	668,480	1,018,937
Direct and Indirect Impact on Employee Compensation ($000)	2,518	40,902	62,171
Direct, Indirect and Induced Impact on Employee Compensation ($000)	3,534	57,019	86,723
Direct and Indirect Impact on Employment ($000)	466	5,876	8,881
Direct, Indirect and Induced Impact on Employment	734	9,242	13,975
2. Region Specific Land Use Charge			
mpact on Agriculture Sector			
Reduction in Farm Sales ($000) (1)	27,739	328,888	543,317
Reduction in Employee Compensation ($000) (2)	2,155	25,555	42,216
Reduction in Farm Employment	305	3,612	5,967
mpact on County			
Direct and Indirect Impact on Sales ($000)	34,743	459,360	763,333
Direct, Indirect and Induced Impact on Sales ($000)	51,930	675,629	1,125,032
Direct and Indirect Impact on Employee Compensation ($000)	2,518	41,339	68,644
Direct, Indirect and Induced Impact on Employee Compensation ($000)	3,534	57,629	95,753
Direct and Indirect Impact on Employment ($000)	466	5,939	9,806
Direct, Indirect and Induced Impact on Employment	734	9,341	15,430
3. Uniform Pumping Charge			
mpact on Agriculture Sector			
Reduction in Farm Sales ($000) (1)	104,454	668,121	920,921
Reduction in Employee Compensation ($000) (2)	8,116	51,913	71,556
Reduction in Farm Employment	1,147	7,338	10,114
mpact on County			
Direct and Indirect Impact on Sales ($000)	130,829	933,170	1,293,847
Direct, Indirect and Induced Impact on Sales ($000)	195,548	1,372,510	1,906,926
Direct and Indirect Impact on Employee Compensation ($000)	9,481	83,979	116,352
Direct, Indirect and Induced Impact on Employee Compensation ($000)	13,309	117,070	162,301
Direct and Indirect Impact on Employment ($000)	1,756	12,065	16,622
Direct, Indirect and Induced Impact on Employment	2,763	18,975	26,154
4. Uniform Land Use Charge			
mpact on Agriculture Sector			
Reduction in Farm Sales ($000) (1)	60,921	146,406	313,512
Reduction in Employee Compensation ($000) (2)	4,734	11,376	24,360
Reduction in Farm Employment	669	1,608	3,443
mpact on County			
Direct and Indirect Impact on Sales ($000)	76,304	183,374	392,674
Direct, Indirect and Induced Impact on Sales ($000)	114,050	274,087	586,926
Direct and Indirect Impact on Employee Compensation ($000)	5,530	13,289	28,457
Direct, Indirect and Induced Impact on Employee Compensation ($000)	7,762	18,654	39,945
Direct and Indirect Impact on Employment ($000)	1,024	2,461	5,270
Direct, Indirect and Induced Impact on Employment	1,611	3,872	8,292

Source:
(1) Data generated from model used in Chapter 1.
(2) Other information derived from analysis using IMPLANQ.

Table 5.1b (Cont.) Impact of Conservation Options Upon Sales, Employee Compensation and Employment

Policy Option	Percent Reduction of Seawater Intrusion 10%	25%	50%
5. Tradable Permit			
Impact on Agriculture Sector			
Reduction in Farm Sales ($000) (1)	104,454	146,406	364,414
Reduction in Employee Compensation ($000) (2)	8,116	11,376	28,315
Reduction in Farm Employment	1,147	1,608	4,002
Impact on County		0	
Direct and Indirect Impact on Sales ($000)	130,829	183,374	456,429
Direct, Indirect and Induced Impact on Sales ($000)	195,548	274,087	682,219
Direct and Indirect Impact on Employee Compensation ($000)	9,481	13,289	33,078
Direct, Indirect and Induced Impact on Employee Compensation ($000)	13,309	18,654	46,431
Direct and Indirect Impact on Employment ($000)	1,756	2,461	6,125
Direct, Indirect and Induced Impact on Employment	2,763	3,872	9,638
6. Region Specific Upper Pumping Limit			
Impact on Agriculture Sector			
Reduction in Farm Sales ($000)	40,118	70,262	200,588
Reduction in Employee Compensation ($000)	3,117	5,459	15,586
Reduction in Farm Employment	441	772	2,203
Impact on County			
Direct and Indirect Impact on Sales ($000)	50,248	88,003	251,236
Direct, Indirect and Induced Impact on Sales ($000)	75,105	131,537	375,521
Direct and Indirect Impact on Employee Compensation ($000)	3,641	6,378	18,207
Direct, Indirect and Induced Impact on Employee Compensation ($000)	5,112	8,952	25,557
Direct and Indirect Impact on Employment ($000)	674	1,181	3,372
Direct, Indirect and Induced Impact on Employment	1,061	1,858	5,305
7. Upper Pumping Limit			
Impact on Agriculture Sector			
Reduction in Farm Sales ($000) (1)	57,938	144,845	289,690
Reduction in Employee Compensation ($000) (2)	4,502	11,254	22,509
Reduction in Farm Employment	636	1,591	3,182
Impact on County			
Direct and Indirect Impact on Sales ($000)	72,567	181,418	362,837
Direct, Indirect and Induced Impact on Sales ($000)	108,466	271,164	542,329
Direct and Indirect Impact on Employee Compensation ($000)	5,259	13,147	26,295
Direct, Indirect and Induced Impact on Employee Compensation ($000)	7,382	18,455	36,910
Direct and Indirect Impact on Employment ($000)	974	2,435	4,869
Direct, Indirect and Induced Impact on Employment	1,532	3,831	7,662

Source:
(1) Data generated from model used in Chapter 1.
(2) Other information derived from analysis using IMPLANQ.

Appendix 6: Economic Impact Model

Appendix 6: Economic Impact Model

There are several basic ways that a grower can respond to changes in water availability: fallowing, deficit irrigation, irrigation technology improvements and crop switching. Our approach emphasizes fallowing and irrigation technology investments; deficit irrigation is more applicable to tree crops than to vegetables and grapes, and crop switching requires large investments in human and physical capital. The discussion of the rationing model in this Appendix leaves open the possibility of adjusting irrigation technologies.

The impact model used to measure the profit implications of pumping taxes and limits to control seawater intrusion extends Johansen's (1972) so called "putty clay" assumptions of fixed proportion technology and a capacity constraint in the short run. The conventional putty clay model assumes that all production technologies must be chosen prior to capital investment in a microunit (e.g., firms, plants, land, or machines), and therefore must be fixed in the short run. For many industries, however, it is conceivable that each microunit can employ a number of input technologies.

Hochman and Zilberman (1978, cited HZ henceforth) show how Johansen's approach can be applied to examine the impact of environmental policies. While useful in assessing policies for many industries, the HZ model does not allow for technology substitution, assuming instead that pollution can be reduced only through a reduction of output. This is clearly not the case in Monterey County agriculture. In our case a microunit can be defined as a single acre of land with a different yield and amount of applied water associated with each available irrigation technology. Controls on groundwater use will not necessarily result in widespread fallowing, although this is likely in the very short-run. Over the longer term, some acres will be farmed with a new irrigation technology, such as drip or some other low-pressure system, that reduces applied water and increases yields.

Consider a competitive, or price taking, industry with many microunits producing a single homogeneous output. Each microunit has a maximum capacity associated with its intrinsic production potential (or quality) and the variable input technology chosen. Denote a vector of possible capacity constraints for microunit i by q_i. Each element q_{ij} of each vector q_i is associated with a per unit input technology j. Each input technology j has an associated cost c(j) and externality $\lambda(j)$ per microunit. The microunits may differ in q, c, and λ. Each producer will maximize quasi-rent to each microunit. Because all input technologies use fixed proportions, each microunit will be employed at full capacity unless all technologies return negative quasi rents, in which case the microunit is shut down. Thus, the objective for a microunit facing z discrete input technologies is to

$$\max(\pi \in \{q_{i1}p - c(1) - t\lambda(1)],[q_{i2}p - c(2) - t\lambda(2)],\ldots,[q_{iz}p - c(z) - t\lambda(z)],[0]\},$$

where p is the output price, c(j) is the unit cost of input technology $j \in \{1,2,\ldots,z\}$, and t is unit cost (or tax) of pollution. The externality may result as a byproduct from the production process or directly through the use of a polluting input. In our case, the externality (e.g. seawater intrusion in the pressure area) is a function of water application and varies roughly as a function of the distance of the microunit from the ocean.

Alternatively, the problem could be examined over a continuum of input technologies. In this case, cost and pollution per-microunit are functions of the input technology j, and capacity is a function of microunit quality α and the input technology j.

$$q = q(\alpha, j)$$
$$c = c(j)$$
$$\lambda = \lambda(j).$$

The objective for each microunit becomes:

$$\max_j \{pq(\alpha, j) - c(j) - t\lambda(j)], 0\},$$

with the first order condition (assuming an interior solution):

$$pq'(\alpha, j) - c'(j) - t\lambda'(j) = 0$$

or

$$pq'(\alpha, j) = c'(j) + t\lambda'(j).$$

This first order condition gives the usual result that marginal total revenue equals marginal total cost. The left hand side gives marginal total revenue: the marginal increase in capacity, q', multiplied by price; the right hand side gives the marginal total cost: the marginal increase in total cost plus the marginal increase in total taxes. Notice that the expression emphasizes *total* marginal relationships as a function of input technology j rather than the usual per unit marginal relationship. Also notice that marginal total cost is only an implicit function of capacity.

The associated second order condition is

$$pq''(\alpha, j) - c''(j) - t\lambda''(j) < 0$$

Notice that a well defined interior maximum does not imply the signs of the first or second derivatives of q, c, or λ.

In the continuous case, input technologies feasible with each microunit form a unit isoquant. Unlike a more general constant returns to scale (CRTS) model, however, each point on the unit isoquant has an associated capacity constraint. Thus, the producer maximizes quasi-rents to the microunit, explicitly recognizing the trade-off between marginal cost and capacity.

To compare this model to the usual per-unit model, consider the following alternative formulation. While the model is ostensibly the same as the one given previously, the interpretation is a little different and perhaps more intuitive. Call $mc(\alpha, j)$ the constant marginal per-unit cost as a function of quality α and input technology j. The model assumes fixed proportions, so the marginal per-unit cost equals the average cost. Thus,

$$mc(\alpha, j) = \frac{c(j)}{q(\alpha, j)}.$$

In this formulation (assuming for now that the pollution tax $t = 0$), the microunits objective becomes:

$$\max_{j}\{\pi = pq(\alpha, j) - mc(\alpha, j)q(\alpha, j)\}.$$

The first order condition for each microunit is:

$$q'(p - mc) = (mc)'q.$$

Here, marginal total revenue (MTR) is the change in capacity multiplied by the change in per-unit markup (p-mc). Marginal total cost (MTC) is the change in per-unit cost multiplied by the capacity.

Returning to the original formulation, the solution to each microunit's maximization problem gives optimal output, input, and pollution quantities $q^*(\alpha, p, t)$, $c^*(\alpha, p, t)$, and $\lambda^*(\alpha, p, t)$ respectively. Aggregating over all microunits, the total supply is

$$Q^s = \int_{\underline{\alpha}}^{\bar{\alpha}} q^*(\alpha, p, t) f(\alpha) d\alpha$$

where f(α) is a function of the density of microunit quality α. The bounds on the integral, $\bar{\alpha}$ and $\underline{\alpha}$, are the highest and lowest quality microunits. In the discrete case of N distinct microunit vintages,

$$Q^s = \sum_{i=1}^{N} s_i q^*(i, p, t),$$

where is s_i the number of microunits of vintage i. In equilibrium, price p is given by the demand function:

$$p = f^D(\sum_i q^*).$$

Now consider the case of just two reasonable input technologies under all plausible taxes t. The input technologies have total costs c_0 and c_1, capacity functions $q(i, c_0)$ and $q(i, c_1)$ across microunits i, and externality per microunit $\lambda(c_0) = \underline{\lambda}$ and $\lambda(c_1) = 0$. For instance, c_0 could be the cost of the input technology employed when t = 0, and c_1 could be the cost of an alternative low-externality technology employed when t becomes sufficiently large. In this case the decision criterion simplifies to:

$$\max\{[pq(i, c_0) - c_0 - t\underline{\lambda}], [pq(i, c_1) - c_1], 0\}$$

If the growers' choice will only take place over the intensive margin, then the high-externality technology is used as long as

$$(pq(i,c_0) - c_0 - t\underline{\lambda}) > (pq(i,c_1) - c_1).$$

Rearranging terms and dividing by $\underline{\lambda}$, the same can be said if

$$\frac{p[q(i,c_0) - q(i,c_1)] - [c_0 - c_1]}{\underline{\lambda}} > t.$$

The left hand side of the above expression is simply the average value product (AVP) of the externality. Thus, the high-externality technology will be used as long as its AVP is greater than the tax t.

If the difference in yields between the two technologies is large, there could be significant price effects entering the AVP decision criterion above; that is, price becomes endogenous. Given N microunits in the industry, equilibrium is specified with N+1 equations: an AVP equation like the one above for each of the N microunits plus the aggregate demand curve.

The model proposed here implies that higher quality microunits (i.e., those with higher capacity for a given input technology) will always value the high-externality technology more than lower quality microunits. This follows because pollution *per microunit* depends only on the input technology employed. Higher quality microunits can always produce more output for any given level of externality. Therefore, as the tax increases, the first microunits to reach the technology switching point will be those of the lowest quality. As lower quality microunits change technologies thereby changing total output, the AVP decision criterion shifts for the higher quality microunits. If the lower quality microunits adopt a higher capacity technology, then price and AVP shifts down for the higher quality microunits, encouraging further exit from the high-externality technology; alternatively, if the lower quality microunits adopt a lower capacity technology, then price and AVP shift up for the higher quality microunits. The latter effect may well characterize the switch from furrow and sprinkler irrigation to drip irrigation.

Appendix 7: Bibliography

Appendix 8:

Potential Benefits from Changes in Irrigation Technology in Salinas Valley

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Potential Benefits from Changes in Irrigation Technology in the Salinas Valley

Executive Summary

Currently, the bulk of vegetable and fruit crops in the Salinas Valley are irrigated using a combination of sprinkler and furrow irrigation. This irrigation system, while relatively efficient, has contributed to problems of over-pumping and groundwater overdraft in the Valley. Programs to promote the adoption of more efficient irrigation techniques, including drip irrigation, have been considered but they are costly and there is uncertainty about whether their benefits outweigh their costs.

This section evaluates the benefits and costs of a policy to improve irrigation management in the Salinas Valley. The section emphasizes the adoption of drip irrigation, but there are a variety of other strategies for improving irrigation efficiency, including better irrigation management and the adoption of other modern irrigation technologies. We have used the adoption of drip irrigation as a proxy for irrigation efficiency improvements in general and have assumed that the benefits and costs of drip adoption are similar to the benefits and costs of adopting other strategies. The evaluation of improvements to irrigation efficiency is made in the following four steps:

1. Estimate current crop applied water demand and crop applied water demand assuming widespread adoption of drip irrigation, based upon County survey data and other sources.

2. Estimate the impact of drip irrigation on irrigation costs.

3. Estimate the physical impact of drip irrigation on groundwater overdraft and the unit cost of that impact.

The principle findings in the report are as follows:

- Survey and other data suggest that drip irrigation would decrease crop AW demand over 25%.
- Drip irrigation would decrease crop applied water demand, and lower pumping costs in the Valley from an average of $120 per acre to an average of $86 per acre. The annual cost of a program to install drip irrigation, net of these pumping cost savings, is $184 per acre
- Drip irrigation would increase aquifer storage in the Salinas Valley 35,706 af per year, assuming 80% adoption of drip irrigation on vegetable and vine cropland in the Valley. The unit cost of adopting drip irrigation to increase aquifer storage is estimated to be $1080/af, assuming no changes to crop yield from drip irrigation.
- The unit cost of drip irrigation, as a means to increase aquifer storage, is probably comparable to the unit cost of other options considered by the County, when crop yield and water quality benefits from drip irrigation are taken into account.

Crop Applied Water Demand in the Salinas Valley

There is great uncertainty about crop applied water (AW) demand in the Salinas Valley. The County conducted surveys of grower water use and cropping/irrigation practices to better estimate crop AW demand. Over 380 farmers completed survey forms in the 1994 survey. Of these, 43 survey forms were chosen on the basis of completeness and accuracy, to represent farming practices in the Valley.

Data from these survey forms suggest that farmers in the Salinas Valley apply an average of 1.8 acre feet per crop acre (af/ac) of water to vegetable crops in the north (pressure and east side zones) and 2.17 af/ac of water to vegetable crops in the south (forebay and upper valley zones) of the Salinas Valley (Table 1). An average of 2.95 af/ac is applied to berries in the north and 1.62 af/ac is applied to vines in the south of the Valley.[1] These data were used to calculate current Unit AW estimates in Table 1 (column 6).

There was too little survey information to estimate crop AW demand for drip irrigated crops, apart from vines and berries. The data suggest that vines receive an estimated 1.37 af/ac under drip, compared to over 2.1 af/ac for vines under sprinkler irrigation. Almost all berry acreage in the County is produced using drip irrigation. Most crop extension advisors believe that drip irrigation would have a significant impact upon vegetable applied water demand. Data provided in a U.S. Bureau of Reclamation and Monterey County Water Resources Agency crop modeling study and discussions with U.C. Davis farm advisors suggest suggest that drip irrigation has the potential to lower vegetable crop applied water over 12" per crop acre below estimates of

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[1]Other studies, based upon theoretical models of crop water use, suggest that less water is applied to crops in the Salinas Valley (Table 1). However, we feel that the survey data is superior to the modeling data and have used the survey crop applied water estimates in this report.

applied water reported in the survey, as shown in column 5. (Table 1, column 7) (U.S.Bureau of Reclamation 1991).[2]

In practice, vegetable applied water under drip irrigation would probably decline less than 12". Drip applied water demand is predicted to be 1.26 and 1.59 acre feet per crop acre for vegetable crops in the North and South regions (Table 1; column 7). Fruit applied water demand under drip is predicted to remain at current drip applied water levels shown in the survey.

These estimates of applied water demand suggest that farmers currently apply a total of 547,238 acre feet to vegetable and fruit crops in the Valley. Full application of drip irrigation would lower total applied water demand 27%, to 394,743 acre feet.

Drip Irrigation Costs

Conversations with U.C. Davis Farm advisors indicate that investment in a drip irrigation system, amortized over the life of the equipment at 7% interest, costs $167/ac. Adding an annual $50 cost for drip tape suggests that the total cost of a drip irrigation system is about $217 per acre (Table 2).

The costs to operate a drip system tend to be lower than the costs to operate a conventional irrigation system. Some of these costs, including labor, pesticide and fertilizer cost savings, were considered relatively minor by U.C. Farm advisors and are not included. However, pumping costs would be significantly lower and an effort is made to include these cost savings. The applied water use figures for conventional and drip irrigation in Table 1 and unit pumping

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[2]The modeling study provided base estimates of water applied to crops using conventional irrigation techniques. The U.C. farm advisors suggested that drip irrigation would decrease water use about 3" per crop acre.

cost estimates in Chapter 1, suggest that average pumping costs on drip irrigated farms are $34 less than pumping costs on conventionally irrigated farms ($120 per acre verses $86 per acre on conventional farms). This suggests that the cost of adopting drip irrigation, net of differences in irrigation cost, would be $184 per acre. Assuming that 67% of farm acreage in the Salinas Valley is double cropped drops the net cost of drip irrigation per crop acre to an average of $121 (Table 2)[3].

Impact of Drip Irrigation on Aquifer Water Storage and Crop Revenue

Water applied to crops in excess of crop evapo-transpiration in the Salinas Valley tends to either peculate to the aquifer, where it may be reused, or to evaporate. Other things equal, any decrease in evaporation caused by changing irrigation practices in the Salinas Valley would decrease net withdrawals from the aquifer and increase net aquifer storage. As a rule of thumb, farm advisors in Salinas and U.C. Davis suggested that drip irrigation would reduce true evaporation about .17 acre foot per acre. This rule of thumb applied to the Salinas Valley suggests that drip irrigation has the potential to decrease true evaporation and increase aquifer storage some 35,706 acre feet per year (Table 3). Full adoption of drip irrigation in the Salinas Valley would cost a total of $34 million, indicating a unit cost of $1,080 per acre foot increase in aquifer storage.

Drip irrigation may have offsetting impacts on crop yield and water quality that would, on balance, lower this cost. Extension advisors in Salinas and U.C. Davis extension faculty indicated that drip irrigation can increase vegetable crop yield anywhere from 0 to 15%, depending upon

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[3]Drip tape is replaced either annually or seasonally depending upon the crop. In this estimate we have assumed that tape is replaced annually.

crop type and irrigation management. A very slight yield increase (1 or 2 %) attributed to drip irrigation would cut the estimated unit cost of drip irrigation by one half or more. No information was available to quantify water quality benefits attributed to drip irrigation, but some irrigation extension specialists believe these benefits are substantial.

Conclusion

Drip irrigation is currently applied to only a small fraction of crop acres in the Salinas Valley. County survey data suggests that this fraction is between 6% and 14% of all crop acres and concentrated almost entirely to berry and vine acreage. The survey also suggests that this fraction has not changed over the last three years. These data suggest that farmers in the Salinas Valley do not find it profitable to adopt drip irrigation, despite crop yield and lower pumping cost benefits attributed to drip irrigation.

However, there are external benefits to drip irrigation in the Salinas Valley, including benefits to aquifer storage and to water quality, that suggest that drip irrigation should be encouraged by the County. The analysis in this Chapter suggests that widespread adoption of drip irrigation would significantly decrease groundwater overdraft, and thus seawater intrusion into the Salinas Valley aquifers. When these benefits are taken into account, it is likely that the cost of drip irrigation would be comparable to the cost of other methods of decreasing groundwater overdraft in the Salinas Valley.

Table 1. Comparison of Survey and CWADS Model Estimates of Crop Applied Water in the Salinas Valley

	1 Crop Acres (ac)	2 Survey Unit Applied Water (AW) (af/ac)	3 Survey Drip Unit AW (af/ac)	4 Survey Sub-sample Size	5 CWADS-Extension Estimate Drip Unit AW (af/ac)	6 Estimate Current Unit AW (af/ac)	7 Prediction Drip Unit AW (af/ac)	8 Estimate Current Total AW (af)	9 Prediction Drip Total AW (af)
North Valley									
Vegetable	153,185	1.80	n.a.	16	0.71	1.80	1.26	275,732	192,247
Berries	4,369	2.95	2.95	3	n.a.	2.95	1.48	12,888	6,444
vines	3,786	n.a.	n.a.			1.62	1.37	6,133	5,186
South Valley									
Vegetable	90,579	2.17	n.a.	18	1.00	2.17	1.59	196,557	143,568
Vines	34,524	1.62	1.37	6	n.a	1.62	1.37	55,928	47,297
	286,442							547,238	394,743

Data Sources:

1 Acreage data aggregated from data used in Chapter 1.
2 1994 unit applied water from 1994 Monterey County Conservation and Water Use Surveys. Pressure and East side included as "North". Forebay and Upper Valley included as "South".
3 Estimated using regression analysis of Survey data.
4 1994 conservation survey included 384 observations.
5 CWADS applied water estimates aggregated from U.C. Berkeley (1995) and U.S. Bureau of Reclamation and Monterey County Water Resources Agency (1991) "Sample CWADS Water Use Calculations Report".
6 Calculated from columns (2) and (3).
7 Calculated from columns (2), (3) and (5). Assume vegetable AW average of CWADS and survey estimates.
8 Calculated by multiplying columns (1) and (6).
9 Calculated by multiplying columns (1) and (7).

Table 2. Impact of Drip Technology on Irrigation Costs

Crop	1 Crop Area	2 Current Unit Pumping Cost	3 Drip Unit Pumping Cost	4 Annualized Cost to Install Drip	5 Net Annualized Cost	6 Net Annualized Cost per crop acre
North Valley	(ac)	($/ac)	($/ac)	($/ac)	($/ac)	($/ac)
Vegetables	153,185	$135	$94	$217	$176	$106
Vines	3,786	$122	$103	$217	$198	$198
South Valley						
Vegetables	90,579	$109	$79	$217	$188	$113
Vines	34,524	$81	$69	$217	$205	$205
Total	282,073	$120	$86	$217	$184	$121

Sources:
1 Acreage data from Table 1 excluding berry acreage. North vine acreage from Chapter 1.
2 Pumping Cost from column (2) and data in Chapter 1.
3 Pumping Cost from column (3) and data in Chapter 1.
4 Annualized drip cost from communication with U.C. Davis extension faculty.
5 Net annualized cost calculated by deducting pumping cost savings due to drip irrigation.
6 Assumes 67% double cropped vegetable acres.

Table 3. Cost and Effectiveness of Adopting Drip Technology to Increase Aquifer Storag

Crop	1 Net Cost of Drip Irrigation ($/ac)	2 Unit Additions to Aquifer (af/ac)	3 Total Additions to Aquifer (af)	4 Unit Cost Additions to Aquifer ($/af)
North Valley				
Vegetable	$176	0.17	20,833	$1,036
Vines	$198	0.17	252	$1,189
South Valley				
Vegetable	$188	0.17	12,319	$1,104
Vines	$205	0.17	2,302	$1,227
Totals	$184	0.17	35,706	$1,080

Sources:

1 Net cost of drip irrigation from Table 1, Column 9

2 Net additions to aquifer from conversations with U.C. Davis extension faculty (assume 2.0 inches per acre resulting from adoption of drip irrigation).

3 Total additions to aquifer calculated by multiplying 80% of crop acreage (Table 1) by .17.

4 Calculated by dividing column (1) by column (2).