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Advanced Wastewater Treatment for Nutrient Reduction: Impact on Sacramento Income and Employment

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We thank the Sacramento Regional County Sanitation District (SRCSD) for data and their assistance in understanding the technical and financial details of the advanced treatment process and their operations, and for financial support of this project.

Executive Summary

Ecological problems in the Sacramento-San Joaquin Delta have raised concerns about nutrient discharges, especially ammonia, from the Sacramento Regional County Sanitation District (SRCSD) wastewater treatment plant that serves most of Sacramento County and West Sacramento in Yolo County. This report evaluates the economic costs to the Sacramento region of investing in an advanced treatment process that would substantially reduce ammonia discharge into the Sacramento River.

The ammonia reduction project would have a $770 million capital cost, and operation and maintenance of the completed facility is estimated at $30 million per year. We estimate that the project will require SRCSD to generate an additional $90 million annually through increased rates and fees. SRCSD is projecting even higher rate increases, because they anticipate larger debt coverage requirements to maintain their bond rating and continued slow growth in their service area. The range of potential rate and fee increases is as follows:

- The typical Sacramento household wastewater treatment bill would increase between $10 and $15 per month ($120 to $180 annually) from their current level of $19.75 per month.
- Government, commercial and industrial users would also face wastewater treatment cost increases between 50% and 75%.
- New development wastewater treatment impact fees would increase from $7,450 to between $11,000 and $18,000 per ESD (equivalent single family dwelling). In-fill development impact fees would increase from $2,800 to between $4,200 and $6,500 per ESD.

In addition to higher bills, the total economic impact of the project was assessed by estimating the negative effects of reduced disposable income on consumer spending, the negative effects of reduced construction activity, and the positive effects of building and operating the wastewater plant. Considering all the effects, the average annual economic impacts over the 30 year analysis period on the Sacramento Region are:

- Annual income loss of $94.4 million.
- Annual employment loss of 390 jobs.

This is a conservative assessment of regional impacts. SRCSD estimates rate increases will be even larger than we assume. We also assume increased impact fees will only have a small effect on the amount of new development, and only reduce the output of the construction industry by an amount equivalent to the increased fee payments. The report assumes no effect on local electricity costs, although the project will generate a 2% increase in SMUD's electricity demand. We assume increased wastewater treatment rates will not be significant enough to affect the location, operation or investment decisions of businesses, and that lost corporate income flows outside the region. Finally, it is important to note that the analysis only examines nutrient reduction, implementing further advanced treatment to reduce other contaminants would more than double the costs estimated in this report.

The results of this study inform planning and regulatory decisions regarding the San Joaquin-Sacramento Delta, and can be compared to analysis we have conducted on other aspects of the Delta issue. In previous analysis, we estimated that reduced agricultural water supplies due to Delta pumping restrictions to protect endangered species result in an income loss of $150 million and 2,000 jobs in the San Joaquin Valley.[1] We have also estimated that the closure of the salmon fishery in 2008 and 2009 created an annual loss in California of about 1,800 jobs and $120 million in income.[2]

[1] "Employment Impacts of Reduced Water Supplies to San Joaquin Valley Agriculture," December 10, 2009. http://forecast.pacific.edu/water-jobs/Pacific-BFC-Water-Jobs.pdf. We will soon release an update of this estimate using new data that shows actual losses were 40% to 50% lower than this estimate. Check our website at http://forecast.pacific.edu for an updated report.

[2] "Employment Impacts of California Salmon Fishery Closures in 2008 and 2009." April 1, 2010. http://forecast.pacific.edu/BFC%20salmon%20jobs.pdf.

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Background

The Sacramento-San Joaquin Delta is in an ecological crisis headlined by dramatic declines in the population of salmon, Delta smelt, and other threatened and endangered fish species. Scientists studying the cause of the ecological decline have identified water pumping operations for the State Water Project and the federal Central Valley Project as a significant contributor to the species decline. Scientists are also exploring other potential causes of species decline, including nutrient discharges, especially ammonia, from the Sacramento Regional County Sanitation District (SRCSD) wastewater treatment plant.

The SRCSD wastewater plant serves most of Sacramento County and West Sacramento in Yolo County. The regional plant began operation in 1982 and provides primary and secondary treatment to the wastewater of over 500,000 households through a pure oxygen activated sludge process. The plant is located in Elk Grove, CA and discharges treated wastewater into the Sacramento River near Freeport. Upgrading the plant to remove most nutrients, including ammonia, requires an investment in nitrifying trickling filters (NTF) and fluidized bed reactors (FBR), and two new pumping stations. The capital costs are estimated at $770 million and on-going operations and maintenance would add an additional $30 million per year.

This report evaluates the economic impact on the Sacramento area of investing in the advanced nutrient reduction process. We evaluate the impact on ratepayers' bill, and how higher costs would affect their spending patterns and jobs in Sacramento area businesses. We also estimate the impact of increased impact fees on construction spending. In addition to the costs, we evaluate job and income creation from the construction and operation of the advanced treatment facility.

The report captures most of the likely economic impacts on the Sacramento region, but does have several important limitations. First, we do not estimate the economic value of environmental changes, such as improvements in Delta water quality from advanced wastewater treatment or increased greenhouse gas emissions from new electricity consumption. Second, the cost estimates and economic impacts are conservative. Rates could increase more than we project, and we generally assume that the rate increases will have little or no impact on the rate of development and business location decisions, and that all lost corporate income flows outside the region and has no multiplier effect on the local economy. We also assume that the project will have no effect on local electricity costs, although it will substantially increase electricity demand in the Sacramento area. The increase in electricity consumption is equivalent to the total increase in electricity consumption in the SMUD service area between 2003 and 2008, a 2% increase. Finally, it is important to note that this analysis only examines advanced nutrient reduction. Additional advanced treatment processes such as microfiltration and UV disinfection have been proposed for SRCSD wastewater treatment, and have even larger costs than the nutrient reduction process examined in this report.

Cost of Advanced Nutrient Removal Process

Cost estimates for the construction and operation of the advanced nutrient removal process were given to us by SRCSD staff. Details on the treatment process and cost estimates are in the Appendix. The project is estimated to cost $771 million dollars to construct. The nitrifying trickling filter process has the highest capital cost of $543 million. The fluidized bed reactors and two pump stations are estimated to cost $166

million and $61 million respectively. Design and construction is expected to take eight years, three years for design and five years for construction. Once the facility is finished, annual operations and maintenance costs are estimated at $30.5 million. Annual labor costs are estimated at $4.5 million, electricity costs of $9.9 million, supplies and chemicals of $9.1 million, and $6.9 million for maintenance and replacement of components.

A large capital expenditure will be financed by issuing bonds. Assuming a 5% interest rate and 30 year amortization period, the $771 million project would generate an annual debt service of $50 million. However, SRCSD will need to increase revenues by more than the amount of new debt service in order to sell the bonds and maintain a strong bond rating. To protect against default risk if revenues or expenses were to unexpectedly change, bond covenants require minimum levels of revenue in relation to debt. For example, the collapse in new Sacramento development during the recession caused SRCSD's revenue from impact fees to decrease by $40 million per year. Despite the large unexpected drop in revenue, SRCSD was able to make all scheduled payments on existing debt because of cash reserves.

For planning purposes, SRCSD's net operating revenue target is 1.4 times current debt service although the minimum required is 1.2. For the $50 million in debt service for the ammonia treatment plant, this amounts to a planning target of an additional $20 million in needed revenues per year for the required financial coverage, and at least an additional $10 million in revenue to reach the minimum requirement of revenues at 1.2 times debt service. For the economic impact analysis, we conservatively use the minimum $10 million level of financial coverage. After adding in the approximately $30 million in operating and maintenance costs, the nutrient reduction project will require an additional $90 million in annual revenues from SRCSD customers.

Following current SRCSD capital cost allocation practices, the $60 million in capital costs will be 70% financed from rate increases to existing customers, and 30% from increased impact fees on new residential and commercial development. The $30 million in additional operating and maintenance costs will be entirely paid by rate increases. Thus, the $90 million in new annual SRCSD revenues is estimated to come from a $72 million increase in rate revenues, and $18 million annual increase in impact fee revenue. Current rates generate a little more than $140 million in revenue, thus the additional $72 million would require an approximately 50% rate increase, an additional $10 per month for a single family dwelling. Government, commercial and industrial ratepayers would experience similar proportional rate increases.

The other $18 million in annual revenue would need to come from impact fees paid by residential and commercial developments. The necessary increase in impact fees is much more difficult to estimate, because it depends on the rate and type of future growth and development rather than a relatively stable base of current ratepayers. Earlier in the decade, SRCSD was adding 10,000 or more ESDs (equivalent single dwellings) per year, but this has dwindled to 2,000 per year during the current recession. We project that population growth will eventually lead to an average of 6,000 to 8,000 new ESDs per year over the 30 year analysis period, and this would require about a 50% increase in current fees to generate an average of $18 million in revenue. This is a very rough, and possibly optimistic, estimate to illustrate the possible change to fees. For the purposes of the economic impact analysis, the amount of the total cost burden on new development, $18 million, is more important than the exact amount of the fees.

SRCSD has made different, more conservative, estimates of anticipated rate and fee increases. We have reviewed their estimates and methodology, and consider their rate estimates to be very plausible, but inappropriate for our economic impact analysis. Their analysis assumes that larger reserves will be needed,

and that growth will be very slow to recover and continue to depress their revenues and financial reserves. The rates estimated by SRCSD represent prudent financial planning, especially given the current economic uncertainty. SRCSD must plan for substantial financial reserves and be financially prepared for more negative scenarios. If more positive results are obtained, the financial reserves can be used in the future for rate stabilization or paying off debt. Our purpose is different, and the lower rate assessment is more appropriate for an academic economic impact analysis. Below we present expected rate increases as a range of possible outcomes, but we emphasize that SRCSD believes our estimates understate the likely increase in rates that will be required.

- The typical Sacramento household wastewater treatment bill would increase between $10 and $15 per month ($120 to $180 annually) from their current level of $19.75 per month.
- Government, commercial and industrial users would also face wastewater treatment cost increases between 50% and 75%.
- New development wastewater treatment impact fees would increase from $7,450to between $11,000 and $18,000 per ESD (equivalent single family dwelling). In-fill development impact fees would increase from $2,800 to between $4,200 and $6,500per ESD.

Economic Impact Methodology and Definitions

The economic impact analysis was performed using an input-output (I/O) model. It generated a detailed representation of the Sacramento County economy through which the project's impacts were assessed. In deriving the model we utilized IMPLAN Version 3 software and 2008 county totals data, the most recent data IMPLAN currently has available for Sacramento County. The full range of economic impacts that result from the project, the *Total Impact* is the sum of the direct, indirect, and induced effects:

- *Direct effects* are the changes in income and jobs related exclusively to the project. This includes all construction costs for building the facility (e.g. infrastructure, equipment, labor, etc.). Direct benefits also include annual operating expenditures (e.g. salaries, supplies, maintenance, etc.). Whether payroll related or associated with the purchase of goods and services, all impacts are directly related to the project.

- *Indirect effects* represent the iterative impacts of inter-industry transactions as supplying industries respond to the increased demands from the direct beneficiaries of the project. An example of an indirect benefit would include a chemical company's new employment and increased purchase of feedstock to meet the demand of the expansion project.

- *Induced effects* reflect household consumption expenditures of direct and indirect sector employees. Induced effects also include the effect on local consumption from changes in disposable income through higher utility rates. Examples of induced benefits include employee's expenditures on items such as retail purchases, housing, medical services, banking, and insurance.

In this analysis, the total, direct, indirect, and induced effects are presented for three categories of income and employment:

- *Employee compensation* includes wages, salaries, benefits, and all other employer contributions. This measures the financial value of associated employment.

- *Proprietor income* consists of payments received by self-employed individuals and unincorporated business owners.

- *Other property income* consists of items such as corporate profits, capital consumption allowance, payments for rent, dividends, royalties and interest income.

- *Employment*, demonstrates the number of full- and part-time jobs generated on an annual basis.

Further details on methodology follow later in the report.

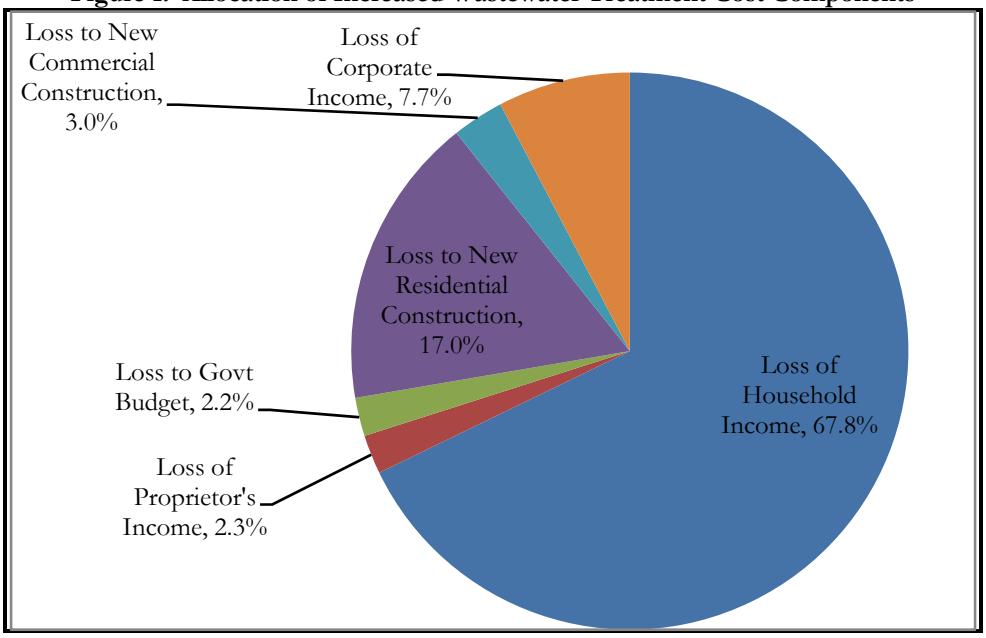
Findings on the Increase in Wastewater Treatment Costs

The total nitrogen removal project will result in $90 million in additional costs annually. Sixty million of these costs are associated with capital expenditure outlays and will be split between rate payers (70%) and impact fees for new connections (30%). The other $30 million in annual costs is associated with operations and maintenance and will be paid by rate payers. We used a detailed list of all SRCSD customers to break down ratepayers between households, government entities, and businesses.

For non-residential ratepayers, increased wastewater costs were assumed not to be significant enough to impact the level of output or location decisions of commercial and industrial users. Thus, the increase in costs was treated as a loss of income to the affected enterprises. All commercial use categories and industrial customers were assigned a 6-digit NAICS code that best matched the description, and we used estimates of proprietor and corporate income by NAICS code to allocate the lost income. Following accepted best practices in local economic impact analysis, we assumed all corporate income flowed outside the area and did not enter the loss into the input-output model. In contrast, losses to proprietor's income were included. Some of the existing commercial and industrial users are public agencies such as schools and prisons. For these customers, the increased wastewater costs ($2 million) were treated as a loss in budget and entered into the input-output model using standard institutional spending patterns. Impact fees were allocated between the commercial and residential construction sectors according to the proportions of residential and commercial users among current customers.

Figure 1 shows the breakdown of costs between different groups. We estimate the $90 million annual increase in rates and fees will directly reduce Sacramento household disposable income by $61 million annually, reduce construction spending by $18 million, reduce business income by $8.9 million, and impose a new $2 million cost on government facilities, primarily schools.

Figure 1. Allocation of Increased Wastewater Treatment Cost Components



Household income losses to rate payers account for the largest share cost, 68% ($61 million), and were distributed across income classes according to latest Census data and entered associated income losses into the IMPLAN model according to these categories as represented in Table 1. The model then estimated the resulting loss in local spending, and the impacts across economic sectors.

Table 1 Treatment Cost Losses to Households by Income in Sacramento County

Annual Household Income	Number of Households	Loss to Households
HH LT 10k	43,871	($5,067,554.15)
HH 10-15k	31,293	($3,614,665.09)
HH 15-25k	63,242	($7,305,104.96)
HH 25-35k	68,329	($7,892,706.07)
HH 35-50k	90,152	($10,413,488.23)
HH 50-75k	108,308	($12,510,693.97)
HH 75-100k	57,935	($6,692,091.58)
HH 100-150k	45,478	($5,253,179.27)
HH 150k+	19,745	($2,280,751.68)
Total Losses to Households		($61,030,235.00)

The increased wastewater costs described above will reduce economic activity and employment in the Sacramento area. Table 2 shows our estimate of a total of 681 lost jobs. Induced job losses are the largest category, and primarily result from decreased local consumer spending from the $61 million decline in disposable income. The 142 direct lost jobs are primarily construction jobs lost due to increased wastewater impact fees.

Table 2 Treatment Cost Employment Effects

	Direct	Indirect	Induced	Total
Total Employment	-142	-48	-491	-681

Business Forecasting Center, July 2010
Data Source: IMPLAN, 2008 Coefficients.

On top of the direct loss in disposable income from higher bills, the resulting decline in economic activity will generate additional income losses. Table 3 details the additional lost income with $29 million annual loss in employee compensation being the largest component. Direct employee compensation impacts are estimated to be equal to $7.7 million per year, indirect impacts $2.1 million and, and induced impacts a further $19.2 million in losses. Annual losses in proprietor income from treatment costs will equal $4.5 million in total effects, and losses to other property income equal $15 million in total effects annually.

Table 3 Treatment Cost Income Effects

	Direct	Indirect	Induced	Total
Total Income Effects	***($9,490,610)***	***($3,239,662)***	***($35,806,386)***	***($48,536,658)***
Employee Compensation	($7,768,464)	($2,107,491)	($19,154,038)	($29,029,993)
Proprietor Income	($1,305,557)	($345,007)	($2,871,170)	($4,521,734)
Other Property Income	($416,589)	($787,164)	($13,781,178)	($14,984,931)

Business Forecasting Center, July 2010
Data Source: IMPLAN, 2008 Coefficients.

The income effects in Table 3 are the losses that are generated from the changes in economic activity in the input-output model. They are in addition to the loss in disposable household and business income that results directly from higher utility rates. The increased wastewater treatment bills will directly reduce Sacramento household disposable income by $61 million annually, and reduce business income by $8.9 million. Combined with the income losses estimated by the input-output model, the total negative impact on Sacramento area income is $118.4 million.

Findings on the Project's Facilities Development

The total nitrogen removal project will require facilities costing $771 million in total. Development of these facilities is estimated to take five years, resulting in our analysis of $154.2 million in annual project expenditures. Allocating these expenditures into an institutional spending pattern for construction of public sewerage systems generated the following results.

Table 4 Facilities Employment Effects

	Direct	Indirect	Induced	Total
Total Employment	553	207	269	1,029

Business Forecasting Center, July 2010
Data Source: IMPLAN, 2008 Coefficients.

During the facilities five years of development, the project should average direct employment of 553 individuals. A further 207 indirect jobs and 269 induced jobs should lead to a total annual average of 1,029 jobs during the treatment facilities development.

Facilities development will average total annual employee compensation effects of $50.5 million. Direct employee compensation impacts are estimated to be equal to $29.5 million per year on average, indirect impacts $10.6 million, and induced impacts a further $10.5 million.

Table 5 Facilities Income Effects

	Direct	Indirect	Induced	Total
Total Income Effects	***$41,129,401***	***$16,148,222***	***$19,526,305***	***$76,803,927***
Employee Compensation	$29,470,959	$10,577,820	$10,475,793	$50,524,571
Proprietor Income	$9,238,190	$1,908,476	$1,525,349	$12,672,015
Other Property Income	$2,420,252	$3,661,926	$7,525,163	$13,607,341

Business Forecasting Center, July 2010
Data Source: IMPLAN, 2008 Coefficients.

Proprietor income from the facilities development will equal $12.7 million per year, in total effects. Direct proprietor income $9.2 million, indirect proprietor income $1.9 million, and induced proprietor income $1.5 million per year on average. Other property income effects from development will equal $10.4 million in total annually on average. Direct other property income $2.4 million, indirect other property income $3.7 million, and induced other property income will equal $7.5 million per year on average.

Findings on the Project's Operations

The total nitrogen removal project's operations will generate $30 million in annual expenditures. The economic impact of these expenditures is estimated through an institutional spending pattern based on annual component estimates provided in a technical memorandum on the treatment process and illustrated in Figure 2 below.

Figure 2 Operating Cost Components

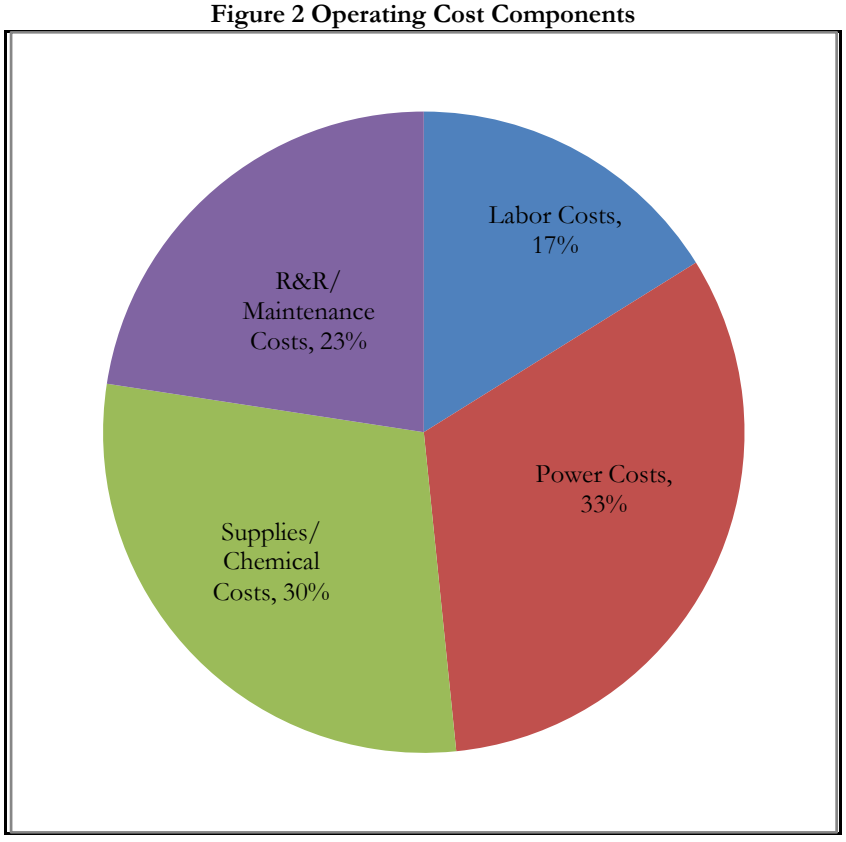


Table 6 Operations Employment Effects

	Direct	Indirect	Induced	Total
Total Employment	60	44	40	144

Business Forecasting Center, July 2010
Data Source: IMPLAN, 2008 Coefficients.

Operations should average direct employment of 60 individuals. A further 44 indirect jobs and 40 induced jobs should lead to a total annual average of 144 jobs from operation of total nitrogen removal project.

Table 7 Operations Income Effects

	Direct	Indirect	Induced	Total
Total Income Effects	***$5,000,000***	***$5,529,231***	***$2,958,488***	***$13,487,727***
Employee Compensation	$4,414,482	$3,012,489	$1,587,074	$9,014,052
Proprietor Income	$0	$585,641	$232,032	$817,674
Other Property Income	$585,518	$1,931,101	$1,139,382	$3,656,001

Business Forecasting Center, July 2010
Data Source: IMPLAN, 2008 Coefficients.

Operations will generate annual employee compensation effects of $9 million in total. Direct employee compensation impacts are estimated to equal $4.4 million per year, indirect compensation impacts $3 million, and induced employee compensation impacts a further $1.6 million. Proprietor income from operations will total $818 thousand per year, in total effects. Other property income effects will equal $3.7 million in total annually.

Conclusion

The costs of advanced treatment to remove ammonia and other nutrients would directly cost Sacramento ratepayers $90 million annually. Most of these costs would be paid by low and middle-income residential households. The increased bills will directly reduce Sacramento household disposable income by $61 million annually, reduce business income by $8.9 million, and impose a new $2 million cost on government facilities, primarily schools. We estimate the increased impact fees would cause an approximately $18 million annual decline in construction spending.

The project would also generate a number of associated economic impacts on the Sacramento economy. Reduced consumer and government spending due to higher sewer bills, and reduced construction spending from higher impact fees would eliminate 681 jobs and create an additional $48.5 million decline in regional income. These losses would be offset by new jobs and income created by the construction and operation of the expanded wastewater treatment facility. During the construction period, the project is estimated to create 1,029 jobs and $76.8 million in regional income. The operation of the facility will sustain 144 jobs and increase income by $13.5 million.

Considering all the effects, the average annual economic impacts over the 30 year analysis period on the Sacramento Region are:

- Annual income loss of $94.4 million.
- Annual employment loss of 390 jobs.

During the 5 year construction period, the net annual income loss would be $41.6 million and there would be a net gain of 348 jobs. After the construction period, we estimate an annual net income loss of $105 million and a net loss of 537 jobs. The primary impact is a loss of disposable income distributed broadly across Sacramento households, with over half of the loss falling on households with annual incomes below $50,000.

This is a conservative assessment of regional impacts. As discussed above, rate increases could be significantly larger than we assume. We also assume increased impact fees will only have a small effect on the amount of new development, and only reduce the output of the construction industry by an amount equivalent to the increased fee payments. The report assumes no effect on local electricity costs, although the project will generate a 2% increase in SMUD's electricity demand. We assume increased wastewater treatment rates will not be significant enough to affect the location, operation or investment decisions of businesses, and that all lost corporate income flows outside the region. Finally, it is important to note that the analysis only examines nutrient reduction, implementing further advanced treatment to reduce other contaminants would more than double the costs estimated in this report.

The results of this study inform planning and regulatory decisions regarding the San Joaquin-Sacramento Delta, and can be compared to analysis we have conducted on other aspects of the Delta issue. In previous analysis, we estimated that reduced agricultural water supplies due to Delta pumping restrictions to protect endangered species result in an income loss of $150 million and 2,000 jobs in the San Joaquin Valley.[3] We have also estimated that the closure of the salmon fishery in 2008 and 2009 created an annual loss in California of about 1,800 jobs and $120 million in income.[4]

[3] "Employment Impacts of Reduced Water Supplies to San Joaquin Valley Agriculture," December 10, 2009. http://forecast.pacific.edu/water-jobs/Pacific-BFC-Water-Jobs.pdf. We will soon release an update of this estimate using new data that shows actual losses were 40% to 50% lower than this estimate. Check our website at http://forecast.pacific.edu for an updated report.

[4] "Employment Impacts of California Salmon Fishery Closures in 2008 and 2009." April 1, 2010. http://forecast.pacific.edu/BFC%20salmon%20jobs.pdf.

Appendix One: Input-Output Methods

The measurement of economic impacts in this analysis was performed using an input-output (I/O) model called IMPLAN. It is, in a sense, a general accounting system of economic transactions between industries, businesses, and consumers that estimates the full range of impacts on sales (output), wages (personal income), jobs (employment), and taxes. IMPLAN creates complete, extremely detailed Social Accounting Matrices (SAMs) and Multiplier Models of local economies that enable in-depth examinations of national, state, multi-county, county, sub-county, and metropolitan regional economies.

IMPLAN was developed in the late-1970s by the United States Forest Service to estimate the economic impact of alternative land management options. In the mid-1980s, researchers at the University of Minnesota began developing IMPLAN for non-Forest Service users. Initially, IMPLAN was based on input-output accounts whose analysis was pioneered in the Nobel Prize winning work of Wassily Leontief. In 1993, a technology transfer agreement with the University of Minnesota led to the Minnesota IMPLAN Group (MIG) taking over development, distribution and support of IMPLAN.[5]

In the late-1990s, MIG enhanced IMPLAN with the release of Version 2 which included a modeling system that created SAMs. With SAMs input-output accounts are extended to include institutional, non-market, financial flows, thereby facilitating the examination of all economic transactions within an economy. Recently, MIG has further enhanced IMPLAN with Version 3 including a gravity model to estimate commodity trade flows between regional economies. This allows IMPLAN to estimate regional purchase coefficients (RPCs) that reflect region specific production patterns down to the county level. Using the derived trade flows between regions, Version 3 can also create multi-region input-output models.[6]

This model provides a comprehensive view of the project's economic impacts in Sacramento County. The BFC used scenarios based on technical memorandum and discussions with the SRCSD to calibrate the economic models and derive direct inputs. Details of the assumptions underlying the scenarios are included in Appendix One.

[5] IMPLAN Website (www.implan.com) Accessed 03/30/2010.
[6] Olson, D and G Alward (2009) "Revised IMPLAN RPCs" V3 Gravity Model Reference Document accessed from IMPLAN Website (www.implan.com) Accessed 03/30/2010.

Appendix Two: Technical Description of Ammonia Reduction Project

The information in this appendix was taken from a March 2009 Technical Memorandum produced for the Sacramento Regional County Sanitation District Engineering Support Services by Larry Walker and Assocites.

Introduction

This appendix includes planning-level analyses of advanced treatment technologies for removal of target pollutants with the ammonia reduction project. The treatment system, represented in the figure below, involves four stages of processing: 1) A High Purity Oxygen - Activated Sludge (HPOAS) process, 2) Nitrifying Trickling Filters (NTF), 3) Fluidized Bed Reactors (FBR), and 4) Chlorine Disinfection. This system significantly reduces nutrients in Sacramento Regional Wastewater Treatment Plant's (SRWTP) entire flow in response to current concerns over nutrient loading in the Sacramento-San Joaquin Delta. The existing HPOAS and chlorination processes at the SRWTP would be retained, but the system will require development of new NTFs and FBRs

Figure A1 The ammonia reduction processing system

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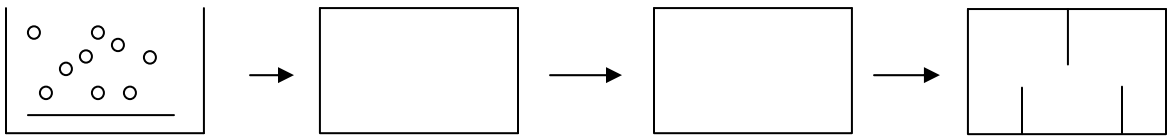

Ammonia Removal - Nitrifying Trickling Filters (NTF)

Biological nutrient removal (BNR) consists of anoxic, anaerobic, and aerobic biological treatment processes designed to remove ammonia, nitrogen, and/or phosphorus from wastewater effluent. BNR can be employed as a suspended-growth process, such as activated sludge or oxidation ditches, or as a fixed-film process, such as trickling filters or biological aerated filters. The selection of a particular BNR process is based upon site specific constraints, including odor, site availability, operational flexibility, regulatory requirements, and compatibility with existing processes.

Nitrification is an aerobic process for the conversion of ammonia to nitrate by nitrifying microorganisms. The nitrifying trickling filter (NTF) is an attached growth (biofilm) method that can be used to remove ammonia from secondary treated wastewater. The fluidized bed reactor (FBR) process is an attached growth (biofilm) method that can be used to remove ammonia from secondary treated wastewater. Secondary treated effluent is pumped and distributed to the top surface of the filter media. Various types of plastic media are used. Wastewater percolates downward through the filter media and is collected in the underdrain. Generally, the denitrifying step precedes the nitrifying step, with an internal recycle.

Advantages and disadvantages of NTF are listed below:

Advantages	Disadvantages
• No chemicals are added in the process.	• Large area required for the process.
	• Low temperature may affect nutrient removal performance; however, facilities can be sized appropriately to account for reduced performance.

Biological Nutrient Reduction - Fluidized bed reactor (FBR)

Two steps are necessary for nitrogen removal. Nitrification is an aerobic process for the conversion of ammonia to nitrate by nitrifying microorganisms. Denitrification is an anoxic process for the conversion of nitrate to nitrogen gas. Generally, the denitrifying step precedes the nitrifying step, with an internal recycle. The nitrifying trickling filter (NTF) and fluidized bed reactor (FBR) processes are attached growth (biofilm) methods that can be used in sequence to remove nitrogen from secondary treated wastewater.

FBRs follow NTFs to provide denitrification in an anoxic environment. The FBR process is an attached-growth biological system that uses denitrifying biomass grown in a sand media to convert nitrate-nitrogen to nitrogen gas with the addition of a carbon food source (synthetic or side stream from upstream processes). Wastewater is fed upwards through a bed of sand at a sufficient enough velocity to fluidize the sand particles that are coated with a biofilm. As the biofilm grows in thickness, it causes the sand media to become lighter in overall density and accumulate at the top of the bed where it can be removed. Process efficiency is controlled by continuously removing the biomass from the lighter particles at the top and returning the clean sand to the bottom of the reactor.

Advantages and disadvantages of FBR are listed below:

Advantages	Disadvantages
• No chemicals are added in the process.	• Large area required for the process.
	• Low temperature may affect nutrient removal performance.

Basis of Cost

The costs presented are based on preliminary layouts, preliminary unit process sizes, and conceptual alternative configurations. Construction costs are estimated from unit costs developed from past SRCSD construction contracts, estimating guides, equipment manufacturers information, unit prices, and construction costs of similar facilities and configurations at other locations.

Operations and maintenance (O&M) costs are based on SRCSD and other similar facilities historical operating costs, estimated manpower needs, resource requirements, and equipment replacement and maintenance needs. A summary of the economic criteria to be used for estimating costs is presented in the table below:

Economic Criteria	
Item	**Assumption**
Costs in Time and Place	Costs are based on January 2009 costs for Sacramento
Escalation in Cost Index	The cost escalation for 2009 is assumed to be 3%
Project Cost Factor	Total of 65 percent which includes the following: • 10 percent for design engineering. • 10 percent for construction management • 15 percent for administration & legal (5 percent design staff support, 10 percent construction management-plant staff DERA project management). • 30 percent for project contingencies
Interest Rate	5 percent for amortization purpose
Amortized Period	20 years

Capital Costs

Capital costs presented in this TM are Class 5 and Class 4 estimates. Unless otherwise noted, the costs were developed using the 90th percentile of Carollo estimates and bid tabs for other Carollo projects. Costs are provided for each treatment process, and, as necessary, pump stations have been included.

While the estimated construction costs represent the average bidding conditions for many projects, variations in bidding climate at the time the facilities are constructed can affect actual construction costs. Further, the size of the facilities may be refined during preliminary design based on the most current operational information available. For these reasons, the actual construction costs may be lower or higher than originally estimated. As mentioned earlier, Class 4 and Class 5 estimates are not as accurate as estimates prepared in conjunction with preliminary or final design. Engineering News Record (ENR) develops and publishes ENRCCIs for 20 cities in the U.S. and 2 in Canada. Sacramento is not one of the cities tracked by the ENR. Therefore, the ENRCCI for Sacramento was estimated by taking an average of the average ENRCCI for the U.S. 20 Cities and the San Francisco ENRCCI. Capital costs for Sacramento are based on an estimated ENRCCI of 9138, which is the average of the January 2009 U.S. 20 Cities ENRCCI of 8549 and the January 2009 San Francisco ENRCCI of 9726. The construction costs presented include contractor's overhead and profit, and construction contingencies. Costs to the owner, such as engineering, legal, administrative, project contingencies, and construction management costs are added to the construction costs. A variable project cost factor of 65 percent is applied to the construction costs to arrive at the total estimated project capital cost. The project cost factor varies depending on the project scope. The basis for estimating capital costs is presented in below. Both escalation and project cost factor adjustments discussed above are included in estimating total capital costs.

Basis for Estimating Project Costs	
Item	**Estimated Cost[1]**
Obtain Base Construction Cost from Carollo Project Bid Tabs and other Carollo project estimates. Adjust this cost to Jenuary 2009 cost for Sacramento, California. • Add 15% of base construction cost to adject to "mid range" of bids • Add 20% of base construction cost for "missed items"	"A" +15% of "A" +20% of "A"

• Adjust base construction field piping cost[2] • Adjust base construction electrical/instrumentation[2] • Adjust base construction sheeting/shoring/piles[2] Subtotal Construction Cost Subtotal Construction Cost • Add 65% of Construction Cost as Project Cost Factor[3] Total Estimated Project Cost	Varies Varies Varies "B" +65% of "B" "C"
Notes: 1) Based on January 2009 costs for Sacramento, California (Estimated ENCCI of 9138) 2) Costs are adjusted based on site-specific conditions. 3) Includes project contingencies, construction management, administrative, engineering and legal costs.	

Construction cost represents the 90th percentile of past Carollo projects unless otherwise noted. Project costs include a 65 percent contingency as described above.

Escalation Rate

Construction costs have historically escalated with time. This trend is expected to continue in the future. Prior to 2003, the use of cost indices such as ENRCCI was a good way to develop escalation estimates for future projects and future project components. These are commodity indices. However, the bidding market has become so complicated and risky that the typical indices are no longer valid for predicting complete project costs. When China entered the market in 2003 and began using high percentages of significant commodities such as cement and steel, the supply in the U.S. became very constricted. This resulted not only in higher prices, but also in project delays that often cost far more than the increase in the commodity prices. Total project costs became more complicated and were driven even higher when the Hurricane Katrina struck the U.S. Gulf coast, shutting down much commodity production and distribution, and raising fuel prices. While the ENRCCI index tracks rising commodity costs very accurately, they do not consider the following risks to the bidding contractor:

• Uncertainty in delivery of commodities to the project.

• Cost of commodities at time of bid differing from cost at time of shipment.

• Increased cost of freight due to rising fuel costs.

• Short supply of skilled labor and supervision.

• Short supply of qualified specialty subcontractors.

Prior to 2003, owners had been using 3 percent to 3.5 percent compounded annually as an escalation factor for Master Plans and Capital Improvement Plans. Currently, due to the economic recession in the United States, commodity prices and the competitive contractor bidding climate are favorable. However, the prevailing opinion among U.S. estimators in the municipal design disciplines at this time is that over the long term (5 to 20 years out), escalation will level off to around 3 percent compounded annually. Thus, the recommended annual escalation rate for SRCSD is 3 percent.

Operations and Maintenance Costs

O&M unit costs are estimated in January 2009 dollars and based on an ADAF flow of 196 mgd that corresponds with 181 mgd ADWF. Costs are provided for each treatment process, and, as necessary, pump stations have been included. The unit costs were obtained by averaging estimates for O&M costs for various Carollo projects, including previous estimates for SRCSD. Where appropriate, more recent Carollo projects were used without averaging. Projects for which O&M estimates were not averaged are noted. The unit costs presented will be used in developing O&M costs for each treatment alternative.

Future Costs and Present Value Sensitivity Analysis

The total project costs were escalated to the projected midpoint of construction for the process. Each treatment train was assumed to take eight years from the start of planning to start of operation with a start of operation year of 2020. The annual O&M cost at the assumed start date of construction and for the lifecycle of facility were also developed for treatment trains A through E. The lifecycle and amortization period were assumed to be 20 years. The escalation rate was assumed to be 3 percent. The future reinvestment costs and years were estimated assuming that 50 percent of the project cost would need to be reinvested throughout the useful life of the facilities, mainly for the mechanical and electrical components. Structural components were assumed to not require significant reinvestment. Reinvestment was assumed to occur on an annual basis.

Land Requirements

Land requirements are not assigned an economic value in this assessment, because it is assumed that the SRWTP has adequate land for tertiary treatment to accommodate average dry weather flow projections to 218 mgd.