An Economic Evaluation of the Colorado River Basin Salinity Control Program

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Dissolved salts (salinity) adversely affect numerous urban and agriculatural users of Colorado River water in California and Arizona. Congress in 1974 authorized a major salinity control program. Studies of general economic benefits from salinity abatement and the cost per unit of salinity reduction expected from specific proposed projects have been developed by the responsible federal agencies, but no project-by-project evaluation has been published. We find a conceptual basis for a substantial downward revision of prospective economic benefits of salinity abatement. Revised benefits are compared with estimated costs, and only for five of the nineteen projects do economic benefits appear to exceed costs.

Salinity (dissolved solids) in the Colorado River adversely affects over 12 million people and one million irrigated acres. Large quantities of dissolved salts enter the river from natural sources, including salt springs, and from the surface runoff from the sedimentary geologic formations common throughout the basin. Man's activities, particularly crop irrigation causing saline return flows, add to the natural salt load. Water use and evaporation from storage reservoirs concentrates existing salts into a smaller volume of water. The U.S. Environmental Protection Agency (1971) attributes 37 percent of the total salt load to diffuse irrigation return flows, primarily from Upper Basin sources, while 55 percent is assigned to natural surface runoff and groundwater flows. Most of the balance arises from reservoir evaporation, as industrial and municipal contributions are negligible.

The Colorado River Basin Salinity Control Act of 1974 authorized construction of works, mostly to be in the Upper Basin, to control the salinity of waters delivered to users in the United States and Mexico. This act was in response to rising concerns in Mexico and in the Lower Basin states of California, Arizona and Nevada. However, in the intervening decade, expected increases in salinity have failed to materialize, and forecasts of future salinity levels have repeatedly been lowered. These revisions preceded or were independent of the large drops in observed salinity levels which followed the extremely high river flows in 1983 and 1984.

The U.S. Bureau of Reclamation (USBR) was given the lead role in implementing the Colorado River Water Quality Improvement Program in Title II of the bill. Four units were authorized for construction and twelve for investigation. The Improvement Program employs a number of technologies to reduce salt pickup from

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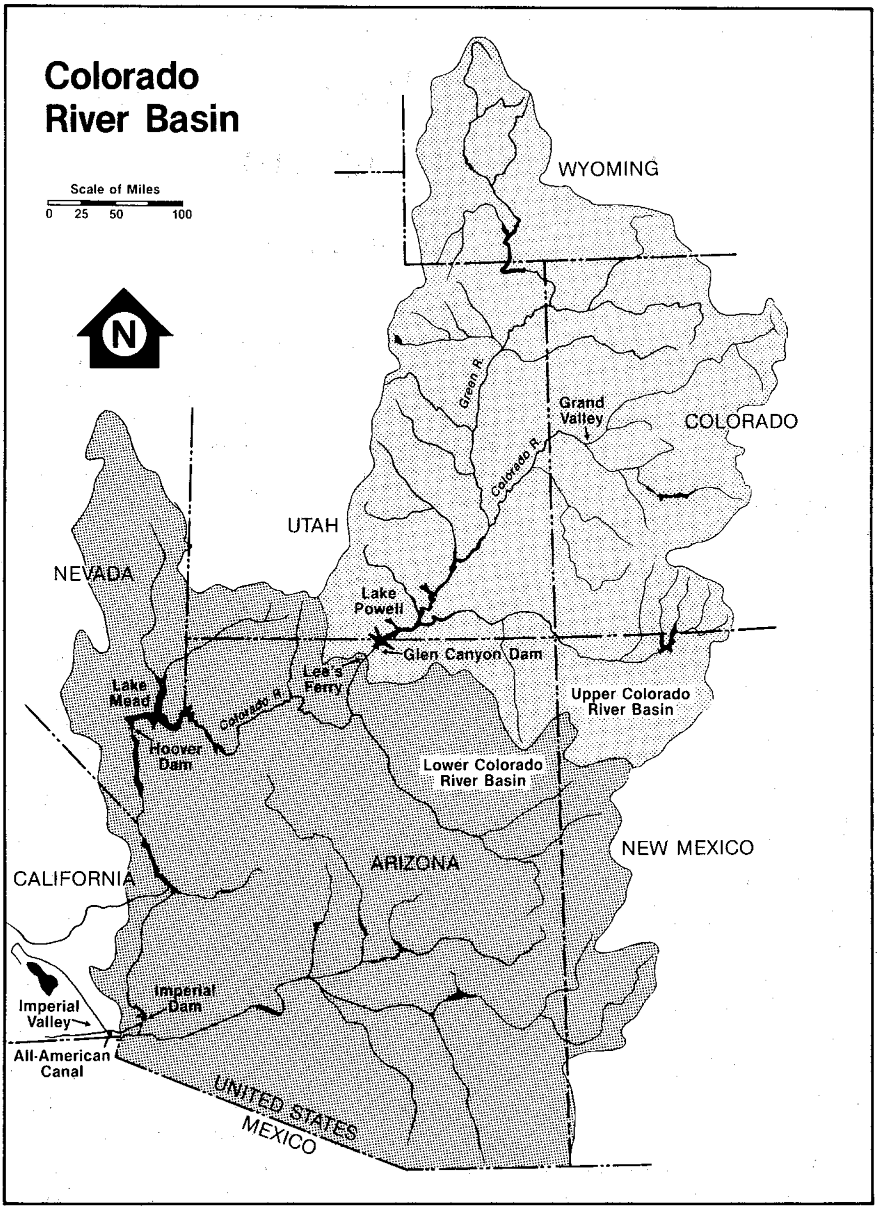

Figure 1. Source: *Resources*, No. 80, Spring 1985, a quarterly publication of Resources for the Future, Washington, D.C.

both natural and man-made sources. USBR has obtained the assistance of the Soil Conservation Service (SCS) to implement on-farm assistance programs planned for ten units. (A desalting plant, which will treat saline drainage water from an irrigation district in Arizona prior to the water's release to Mexico, is also funded under the program. This investment is not analyzed here.)

Economic appraisal of Colorado River Basin salinity control began with the U.S. Environmental Protection Agency's (1971) analysis. Anderson and Kleinman summarize a subsequent regional task force's studies of agricultural, municipal, and indirect salinity damages. Related investigations have been reported by Oyarzabal and Young concerning impacts in Mexico and Boster and Martin regarding central Arizona. The U.S. Bureau of Reclamation (1980) summarized the government's analysis of expected economic impacts.

The Colorado Water Quality Improvement Program has overseen studies of the costs of specific salinity control projects (USBR, 1983). Although the total program cost could exceed one-half billion dollars, little professional discussion of the program has ensued. The USBR, for its part, has chosen a "cost-effectiveness approach." The cost (in dollars per milligrams per liter) of annual salt load reduction in the River is estimated, and priority given to those projects exhibiting lowest cost per unit of salt reduction. Generalized Lower Basin benefits of salinity abatement have also been developed (USBR, 1983:21). Curiously, however, no direct project-by-project comparison of benefits and costs has been publicly reported. Costs are identified in differing places and format from reported benefits, and only a persistent specialist is likely to succeed in piecing together the total picture. There are indications that federal officialdom, while willing to prioritize projects according to cost-effectiveness, would prefer not to evaluate the program on a full economic efficiency criterion. We believe, in contrast, that the economic efficiency criterion should play a major role in evaluating this program, and that only those projects should be funded for which the economic gains to downstream water users clearly outweigh costs.

From our review of the procedures employed in developing the economic benefit estimations reported by the Bureau of Reclamation, it appears that the treatment of benefits overlooks several important conceptual issues. We believe that the official estimates significantly overstate the downstream damages caused by the Colorado River and therefore overstated the economic benefits of salinity abatement. The objective of this article is to report the assumptions and procedures of our reevaluation of the issue, and to provide a project-by-project examination of the economic feasibility of the salinity control program.

Procedure

Benefits of salinity control are defined in terms of "economic damages avoided." Our general approach is to re-estimate agricultural damages-avoided and update the municipal damages-avoided estimates from the earlier basin-wide impact study (USBR, 1980). These revised damages-avoided estimates are then adjusted to account for the several years required for salt pickup reductions from the Upper Basin control projects to be recorded as lower salinity at Imperial Dam. Expected annual benefits are compared with estimated equivalent uniform annual costs for each of nineteen projects to assess economic feasibility. Economic feasibility is defined as real annual equivalent benefits in excess of real annual equivalent costs (James and Lee, pp. 509–12).

Costs and Cost-Effectiveness

Due to lack of both expertise and resources, we utilize without adjustment the federal estimates of project costs and of the physical reductions in salt loading (USBR, 1980). However, previous experience suggests that the estimates of both project costs and effectiveness in reducing salt are highly problematical. There is limited direct knowledge of the physical and hydrologic relationships underlying the salt-loading process, and experimentation to refine knowledge is expensive and time-consuming when it is possible at all.

Hydrologic Linkages

Salinity in the Colorado River is a rather unusual nonpoint water quality problem in that the pollution sources are geographically far removed from those damaged by salinity. Most salt loading occurs in the Upper Basin, while adverse salinity effects are registered several hundred miles away. The Imperial Valley experiences about ninety percent of the total agricultural damages in the U.S. portion of the basin (Kleinman and Brown, 1978). In fact, both the major users of the Colorado River water, the Imperial Valley and the Metropolitan Water District of southern California, lay outside the Colorado River Basin.

Some hydrologic assumptions are needed to compare the benefits with the costs of this long distance externality. Although heavily studied, knowledge of the hydrology of the Colorado River is far from perfect. The hydrologic state of the art is embodied in USBR's Colorado River Simulation System. (See USBR, 1983:107). This analysis is based on the assumptions in that simulation model.

The first major assumption relates salt loading in the Upper Basin to Lower Basin salinity levels. The salt loading relationship adopted is that 10,000 tons added to the river above Parker Dam equals 1.01 mg/liter at Imperial Dam (USDI, 1983: 45). (Equivalently, 9,900 tons equals 1 mg/liter) Each ton of salt removed from upstream is assumed to result in exactly one ton less salinity at Imperial Dam. [If substantial quantities of salt are being precipitated out of the water in the system of reservoirs, as the evidence increasingly suggests, (Paulson and Baker; USBR, 1983: 108–10) salinity control efforts would be proportionately less effective.]

The second assumption concerns the time it takes salts to pass from the Upper Basin through all the reservoirs to the Imperial Dam. The USDI (1983:45) assumes a hydraulic retention time of 5 to 7 years for salts to pass through Lakes Powell and Mead to impact Lower Basin water users. Ninety percent of salinity benefits is expected to be registered at Imperial Dam at the end of that period. This is a significant point, because it means that damages avoided must be discounted over this period to establish a net present value for comparison to salinity control costs, a point overlooked in previous economic appraisals.

For lack of a precise lag function, we assume a hydraulic retention time of six years to achieve one hundred percent of salinity benefits. Fifteen percent of the benefits are assumed to accrue at the end of each of the first five years with the remaining twenty-five percent coming in the sixth year. (This assumption is probably overly favorable to feasibility, as the time distribution of impacts is likely to be skewed towards later years.)

Agricultural Benefits

We adapted the procedure first developed by Moore, Snyder and Sun to estimate damages-avoided, or the benefits of salinity control to agriculture. Two linear programming models of Imperial Valley agriculture were developed. (Full details and assumptions are in Gardner.) One model, reflecting production at 800 mg/liter, approximates the current situation. (The average salinity from 1978–82 was 804 mg/liter.) A second model simulating 1,100 mg/liter salinity conditions represents maximum future salinity conditions, since current USBR forecasts without salinity control are 1,024 mg/liter in 2,000 and 1,089 mg/liter by 2,010 (USDI, 1983: 47). The difference in net farm income between the two models provides our estimate of agricultural damage caused by a 300 mg/liter increase in salinity. This total damage estimate is converted to an estimate of average marginal salinity damage per mg/liter.

The benefit estimates derived below are

"average" benefits for the range of 800 mg/liter to 1,100 mg/liter of dissolved solids. This formulation serves to overstate benefits (to an unknown degree) for two reasons. The first is that because of potentials for alterations in crop mix and water use technology as salinity increases, the damage function is most probably nonlinear, increasing at an increasing rate. Second, the likely average level of salinity over the future planning period without the control program is less than the 950 mg/liter implicitly assumed in the federal analysis. Hence, the appropriate base from which to measure benefits, even before the high flows which diluted salinity in 1983 and 1984, would be in the 800–900 mg/liter range. Thus we believe the marginal agricultural damages are actually somewhat less than reported here.

The model. Agriculture in the Imperial Valley is an extremely diversified, year-round enterprise. More than one-fourth of the 450,000 acres of cropland are double-cropped. The extremely arid region diverts over 2.5 million acre-feet of water annually from the Colorado River. Each linear program consisted of 76 crop production activities spread over five field crops, nine vegetable crops, two soil drainage conditions, and two irrigation frequencies. The predominant doublecropping options were each combined into single activities.

Crop budgets and water use estimates were adapted from the Imperial County Cooperative Extension Service (1982). Harvest costs were varied with yield. Crop prices are real 1977-81 averages, expressed in 1982 dollars.

Proportional constraints were imposed on the degree to which each crop could be produced on well-drained soils. This added realism by simulating heterogeneity of soil distributions and cropping rigidities caused by marketing contracts. These constraints limit the maximum response farmers in the model can make to increased salinity. This is thought to be more realistic than earlier approaches which allowed switching the higher valued crops entirely to well-drained soils. (The general format of the model is given in Table 1.)

Crop yields. Since the model reflects productivity on two soil types and under two irrigation frequencies, published 1977–81 District average yields were adjusted according to agronomists' judgments to derive the expected yield under each of these four alternatives.

In addition, yield declinations were estimated for an increase in irrigation water salinity from 800 to 1,100 mg/liter. The yield declinations were calculated from the effective soil saturation extract conductivities by salinity level and soil type (as reported by Robinson, 1978:90). They are "effective" conductivities in that they were adjusted downward to reflect the significant amounts of gypsum (calcium sulfate) in the soil and water. (Gypsum contributes to measured salinity, but is relatively less detrimental to plant growth.) These conductivities were used with the expected yield decrements from increasing soil salinity estimated by Kleinman and Brown (p. 121).

This method allows the estimation of yield decrements on poorly drained soil at a given salinity level, as well as decrements from increased salinity. Yields on each soil type were estimated using five-year Imperial County average yields, together with the expected yield decrements and the crop distribution on soil types reported by Robinson (p. 89). Alfalfa is moderately sensitive to salinity, while the other field crops are more tolerant. Vegetable crops generally are more salt sensitive. Lettuce yields, in particular, decline rapidly as soil salinities increase. Carrots and onions are also sensitive to salinity, but are grown exclusively on well-drained soils.

The model was validated by comparing projected crop acreage and water use in the 800 mg/liter model with recent experience. Irrigation water requirements

TABLE 1. Imperial Valley Model: Selected Resource Constraints and Requirements.

	Acreage Constraints		Proportional Constraints[b]				Water Requirement[c] (Acre-Feet/Acre)
			800 Mg/liter		1,100 Mg/liter		
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	
Land Constraints							
Crops		580,000					
Well drained land		140,000					
Poorly drained land		310,000					
Doublecropped, well drained land		100,000					
Doublecropped, poorly drained land	30,000						
Water Constraint							
(Acre-feet)		2,566,000					
Crop Constraints							
Alfalfa[a]	150,000		30	40	30	50	6.3
Cotton		60,000	10		10		5.4
Sudangrass	22,000	35,000	30	40	30	40	3.2
Sugar Beets	35,000	50,000	3	10	3	10	7.1
Wheat	100,000		10	30	10	30	2.7
Asparagus	2,500	4,000		0		0	5.8
Broccoli	1,000	4,000	65	75	65	90	4.7
Spring Canteloupe	4,500	7,500	60	80	60	90	4.1
Fall Canteloupe	4,500	7,500	60	80	60	90	2.5
Carrots	6,000	8,000	100		100		5.8
Lettuce	37,000	45,000	65	75	65	90	3.8
Onions	4,500	7,500	100		100		4.7
Tomatoes	1,500	3,500		85		90	7.4
Watermelon	1,000	5,000	60	80	60	90	3.4

[a] Alfalfa establishment requirement—1 acre establishment for every 3 acres alfalfa.
[b] Percentage of total crop acreage grown on well drained land.
[c] Acre-feet per acre of water applied to field.

were adjusted to make implied aggregate water use match historical deliveries.

Agricultural benefit estimates. Benefits are defined in terms of annual "damages-avoided" per mg/liter reduction in salt concentration. Damages are measured by comparison of annual net returns to land, water, management and risk at various salinity levels.

The results from the 800 and 1,100 mg/liter models show that the increase of 300 mg/liter caused returns to land, management, and risk to decline by $113.4 million, equivalent to an average of $46,300 per mg/liter. By way of comparison, the Moore *et al.* damage estimates (converted to 1982 dollars) amount to $34,380 per mg/liter between 480 and 960 mg/liter and $52,870 per mg/liter from 960 to 1,280 mg/liter. USBR (1980:8) estimated average salinity damage in the 800 to 1,110 mg/liter to be $15,600 in 1982 dollars. (The large difference here appears to stem from the use in our model of proportional constraints to limit cropping pattern adjustments and to the fact that USBR did not extrapolate higher yields on the best soil from the average valley wide yield, which led to smaller absolute yield decrements.)

The $46,300 per mg/liter damages in the Imperial Valley can be extended to

TABLE 2. Municipal Damages from Salinity, or Municipal Benefits of Salinity Control.

	Total Lower Basin	Metro Water District of So. Cal.	Arizona Project Area	Lower Main-stream Area
Annual Damage Per Household				
(1982 $/mg/liter)		$0.2442	$0.1655	$0.1677
Number of Full Service Equivalent Households				
1983–87	1,820,000	1,570,000	0	250,000
1988–2032	1,092,000	597,000	245,000	250,000
Annual Benefits of Salinity Control				
(1982 $ per mg/liter)	308,300			
Lagged Benefits[a]	218,700			

Source: adapted from USBR, 1980.
[a] Lagged benefits have been discounted to reflect approximate six-year retention time of the reservoir system between the upstream project locations and the points of use.

agriculture in the entire Lower Colorado Basin by accepting the USBR (1980) estimate that Imperial Valley damages are about 90 percent of the total. This assumption translates to (in 1982 dollars) $51,400 per mg/liter damages to agriculture in the Lower Basin.

We further adjust for the hydraulic retention time of the river and reservoir system. Using the hydrologic assumptions described above and an eight percent discount rate, the present value of total annual agricultural benefits of salinity control becomes $39,100 per mg/liter or $3.95 per ton of salt removed. (We adopted the view that the social discount rate should reflect, in this case, the opportunity cost of displaced private spending, further adjusted for the high risks of salinity control projects. Our chosen rate also closely approximates the Water Resources Council mandated rate for fiscal year 1983.)

Municipal Benefits

Due to limitations on research resources, this analysis utilizes previous reports (Anderson and Kleinman, 1978:19; d'Arge and Eubanks; and U.S. Bureau of Reclamation, 1980) for estimates of the municipal benefits of salinity control. Those estimates were based on cross-sectional surveys of Lower Basin cities whose water supplies differ in salinity. Plumbers and appliance dealers in each area were asked to estimate average lifetimes of various plumbing fixtures and water using appliances. Generally, the lower the salinity of the water the less often fixtures must be replaced, and the less the salinity damages. In addition to capital replacement costs, estimated damages avoided include the costs of bottled water, additional detergents, and central water softening needed to mitigate the more saline water. The annual costs per household are converted to 1982 dollars and listed in Table 2.

The costs must be multiplied by the number of households to get annual area municipal damages. Estimates of household numbers are taken from USBR (1980: 14). (In practice, Colorado River water is often blended to lower the concentration below the recommended level of 500 mg/liter. Therefore, an estimate of equivalent full service households which could be served solely with Colorado River water is used.) For the Metropolitan Water District of southern California 1,052,000 acre-feet of water are assumed to be used annually for municipal purposes, with a cutback to 400,000 acre-feet after 1987. Annual use is assumed to be 0.67 acre-feet per household.

An estimate of 245,000 full service

TABLE 3. Economic Feasibility of SCS On-Farm Salinity Control Units.

Unit	Non-discounted Total Benefits[a,b]	Non-discounted Total Costs[c]	Present Value of Total Benefits[d]	Present Value of Total Costs[d]	Benefit/ Cost Ratio
Grand Valley	$67,600,000	$60,100,000	$19,729,000	$35,735,000	0.6
Uinta Basin	$39,520,000	$91,700,000	$11,144,000	$52,569,000	0.2
Virgin Valley	$19,351,000	$4,900,000	$8,537,000	$4,404,000	1.9
Maopa Valley	$10,134,000	$9,000,000	$4,336,000	$7,842,000	0.6
Lower Gunnison	$174,203,000	$177,500,000	$50,227,000	$104,214,000	0.5
Price-San Rafael	$52,000,000	$22,800,000	$17,594,000	$15,730,000	1.1
Upper Virgin River	$5,200,000	$2,600,000	$2,201,000	$2,257,000	1.0
McElmo Creek	$29,647,000	$29,000,000	$10,877,000	$21,671,000	0.5
Mancos	$10,400,000	$11,100,000	$4,404,000	$9,575,000	0.5

[a] $39,100 direct agricultural benefits + $218,700 municipal benefits = $257,800 per mg/liter or $26 per ton of salt removed. Benefits are discounted for a six year hydraulic retention time at 8%.
[b] Assumes a 20 year life for on-farm improvements.
[c] Estimated total costs over the life of the program, including construction, technical assistance, monitoring and evaluation, and extensive education costs. Source: U.S. Soil Conservation Service, 1983.
[d] Discounted at 8%. Assumed 1) all units begin construction in year 1, 2) all costs are incurred in proportion to construction costs at the beginning of each year, and 3) salinity reduction begins at end of year construction costs are incurred and occurs in proportion to costs incurred that year.

equivalent households was similarly derived for the Central Arizona Project area. A 250,100 household estimate for the Lower Main Stem region is based on expected growth in the region.

Municipal benefits from salinity control can thus be estimated for each year of the 20 year planning horizon that represents the life of on-farm salinity control measures. This benefit stream is discounted at 8 percent interest to obtain the present value of municipal damages avoided from the reduction in salinity. Multiplying by the capital recovery factor for 20 years and 8 percent converts the present value of the uneven stream of benefits to an estimate of average annual municipal salinity damages avoided of $308,300 per mg/liter. Then we discount for the river's hydraulic retention time, yielding a municipal salinity control benefit estimate of $218,700 per mg/liter, or $22.05 per ton of salt removed. (Although we attempted to use the same assumptions as given in USBR (1980) our derived estimate is somewhat less than used in later USBR reports.)

These estimates ignore any potential intangible benefits, such as health costs or the possible aesthetic disutility of saltier water. No authority, however, has suggested that these possibilities are of any significance. The above damage estimates might also prove low if water conservation efforts lower average household water use, allowing the number of households served by a fixed water supply to increase. However, new technologies may be developed that help ameliorate salinity damages. Also, the model does not allow replacement with the lowest cost alternative. For example, copper water pipes or cast iron wastewater pipes would prove less costly than galvanized steel pipe over time (d'Arge and Eubanks, p. 264; Anderson and Kleinman, p. 21).

Secondary (Indirect) Economic Impacts

An important difference between our estimates of salinity damage and those developed by USBR is in the treatment of secondary economic impacts. The USBR (1983) incorporates secondary benefits from agricultural damage abatement in the amount of $128,000 per mg/liter (developed from regional impact multipliers), into their total estimates of damages avoided. We take the contrary position, argued forcefully by McKean and others, that secondary impacts are not properly included in appraisals with a national economic efficiency criterion. Since the alternative public or private expenditure of funds invested in the project in question would themselves generate secondary impacts elsewhere in the economy, secondary impacts represent no real net gain to society. Further, in this particular instance, the secondary impacts claimed in the federal analysis appear to be incommensurate with strict willingness to pay benefit and cost measures, in that they are not measures of *net* indirect income, but are estimated *gross* indirect monetary impacts. Finally, the federal analysis of secondary impacts is inconsistent, in that only the agricultural-related impacts are claimed. Secondary impacts for the household sector similarly analyzed would be negative, reflecting reduced household outlays for salinity-induced benefits. If a symmetric approach were taken, the negative urban secondary effects would swamp the positive secondary impact from agriculture.

Total Benefits of Salinity Control

Combining annual agricultural benefits of $39,100 per mg/liter with annual municipal benefits estimated at $218,700 per mg/liter, we obtain a total salinity control benefit estimate of $257,800 per mg/liter, or about $26 per ton of salt removed from the river.

The Bureau of Reclamation estimate of $513,300 per mg/liter (USBR, 1983:21) when updated to 1982 dollars converts to $51.90 per ton of salt removed from the river. USBR benefit estimates per ton of salt removed are nearly twice as large as those of the authors. Most of this difference is accounted for by our discounting for retention time and not including secondary benefits.

Economic Feasibility of Salinity Control

The revised salinity control benefit estimates can now be compared to government estimates of the cost of salinity control efforts. Economic feasibility here means that real economic benefits exceed real economic costs, both measured in uniform annual equivalents.

SCS On-Farm Projects

The Soil Conservation Service is actively engaged in planning and implementing on-farm irrigation improvement programs for salinity control in several areas of the Upper Colorado River Basin. Cost and salt reduction estimates were available for nine salinity control units. Each relies on irrigation system improvements to reduce deep percolation and salt load, though some units include the lining of off-farm irrigation laterals.

Our benefit estimates are compared to the SCS estimates of costs in Table 3. Nondiscounted benefits and costs are shown, together with their present values as if all units began construction this year and were completed according to SCS timetables. Total costs were assumed to be incurred at the same rate as construction costs. Salt reductions were assigned in the same proportion as costs and at the end of the year costs were incurred. This is a generous assumption since not all construction may be finished in one year, and some irrigation improvements may take time to deliver their full benefits. Using our benefit estimate of $26 per ton, only three of the nine SCS salinity control programs are feasible.

These SCS project benefit-cost ratios are understimated in that irrigation labor savings resulting from on-farm improvements have not been counted. Such reductions in associated costs would normally be subtracted from program costs to get a net social cost of salinity control. Our re-

TABLE 4. Economic Feasibility of U.S. Bureau of Reclamation Salinity Control Units.

Unit	Annual Cost Per Mg/liter Salinity Reduction[a]	Tons of Salt Removed Annually[b]	Annual Cost Per Ton of Salt Removed	Benefit/ Cost[c]
Paradox Valley	$107,000– $266,000	180,000	$10.80– $26.90	2.4– 0.9
Grand Valley—Stage One	$642,000	24,000	$69.30	0.4
Overall	$597,000	280,000	$60.30	0.4
Las Vegas Wash	$102,000– $114,000	71,000	$10.30– $11.50	2.5– 2.2
La Verkin Springs	$1,578,000	103,000	$159.30	0.2
Lower Gunnison Basin	$812,000	141,000	$82.00	0.3
Uinta Basin	$960,000	24,000	$97.00	0.3
McElmo Creek Basin	$820,000	24,000	$82.80	0.3
Glenwood-Dotsero Springs	$908,000	314,000	$97.10	0.3
Big Sandy River	$712,000	75,000	$71.90	0.4
Coal Slurry Pipeline	$256,000– $552,000	351,000– 531,000	$25.90– $56.00	1.0– 0.5

[a] From USBR's CRWQIP Status Report, 1983:18, updated to 1982 dollars by the GNP deflator.
[b] Assumed 9,900 tons of salt equals 1 mg/liter at Imperial Dam.
[c] B/C ratios derived by dividing column 3 by estimated annual benefits (damages-avoided) per ton of salt removed ($26 per ton). See text for explanation.

lated work on other on-farm salinity control actitivies indicate the value of labor saved can offset as much as one-fourth to one-third of project costs (Gardner and Young). However, reducing SCS costs by labor savings of that magnitude would not change the conclusions regarding the six infeasible units in Table 3.

A second consideration is that SCS project costs are made considerably more expensive because the choice of the improvements made in each area is a technical and political one. Several alternatives were developed for each unit, and the public was invited to help in choosing one for implementation. In the case of the Grand Valley, Lower Gunnison, and McElmo Creek units, the preferred alternative was 35 to 70 percent higher in cost than the least cost option. (See, for example, U.S. Soil Conservation Service, 1981b:3). Farmers, of course, choose the plan that benefits them most, but the cost to the public of gaining farmer cooperation is thereby increased. Some addition to social cost may be necessary when farmers are assumed to have no liability for their salt discharges. Nevertheless, the inclusion of less cost-effective activities—such as some sprinkler and drip irrigation systems, land leveling, and range improvements—tends to reduce the overall economic feasibility of a project.

USBR Salinity Control Projects

Cost estimates for relevant Bureau of Reclamation salinity control units either under construction or investigation, (USBR, 1983:18) were updated to 1982 dollars. These costs are compared in Table 4 with the authors' benefit estimate, adjusted to reflect fifty-year USBR project lives (versus twenty years for on-farm improvements).

Table 4 shows that benefits exceed cost estimates for only two of eleven projects. Only the Paradox Valley and Las Vegas Wash units appear economically feasible with all benefit estimates. The Paradox Valley unit consists of pumping brine from below the Dolores River and disposing of it in deep wells. Municipal wastewater and irrigation return flows would be collected and bypassed around the salty Las Vegas Wash.

In contrast, the Grand Valley, Lower Gunnison, Uinta Basin, and McElmo Creek units are all canal and lateral lining projects that do not pass the benefit-cost test. The LaVerkin Springs unit has such a low return that it is no longer under official consideration.

In general, the benefit-cost ratios for SCS on-farm salinity control programs are higher than the ratios for the more structural projects. This conclusion is reinforced by the fact that SCS project costs probably are overstated because of the omission of labor savings benefits.

Conclusion

From an economic efficiency standpoint, only five of the twenty projects analyzed above warrant consideration for construction. Abandoning the remaining projects would avoid irreversible commitments of funds to nonproductive social investments at a time when federal budget deficits are critically high.

The construction of these five units, if current projections of their effectiveness are borne out, would eventually lower salt discharges by about 400 thousand tons per year. Lower Basin salinity could be expected to fall by about 40 mg/liter. This decrement in salinity will provide a noticeable benefit to downstream users or could offset the effects of upstream development. Given the recently lower salinity levels of 816 mg/liter in 1981 at Imperial Dam and 732 mg/liter in 1983 and the eventual completion of the desalting plant, plus this amount of salinity control, the United States should have no problem meeting its obligations to Mexico (based on 879 mg/liter) in the foreseeable future.

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