CHAPTER 7

STRATEGY FOR COMPARING ALTERNATIVES

"… all aspects of water management would be improved by planning that would maintain flexibility for the future, foreclose as few choices as practicable, and put fresh demands on science to predict consequences and to provide alternatives to meet changing needs." Gilbert F. White (1966), *Alternatives in Water Management*, National Academy of Sciences, Washington, DC, p. 48.

Many options exist for addressing California's water resources problems. Structural options are examined in Chapter 3. Chapters 4 and 5 discuss non-structural options that require institutional and regulatory changes. Traditional structural options include new or expanded surface water storage and conveyance. New structural options are becoming possible due to both new technology and the rising cost of developing new water sources. These new options include advanced treatment to utilize wastewater and brackish and saline water. These options to overcoming the present and projected imbalance between supply and demand can be complimented by a series of non-structural measures. The ability to increase supplies through improved co-ordination and operation of surface water facilities alone probably remains limited. Conjunctive use of surface and ground water is increasingly advocated as a means to harness 'surplus' winter runoff to recharge aquifers in wet years (NHI 1998). Water transfers and water markets are also being examined as a reallocation mechanism to boost economic revenues and close the gap between supply and demand.

Chapter 6 introduces the CALVIN model, a new tool for rapidly screening and identifying both structural and non-structural options that promise significant economic benefits. The present chapter builds on the foundations of previous chapters to explain how this new modeling tool will be used systematically to explore the myriad of options available to the state's water managers and policy makers. This exercise is only part of the need to develop, test, and refine promising alternatives.

SINGLE VS MULTIPLE MODEL RUNS

Results from a single model run of CALVIN represent an 'optimal' solution or set of operations for one particular configuration and set of the physical infrastructure, one set of economic value functions and one set of environmental and policy constraints. 'Policy' in this sense refers to any set of rules or limits that constrain reservoir releases, stream diversions and allocations. A single model run, in isolation, will reveal how the system could be optimally operated, the level of shortages and reliability of supplies for the modeled scenario. However, economic values from the model are more meaningfully assessed in comparison to other model runs with different inputs. It should be reiterated (see Chapter 6) that only variable costs that are a function of flow or storage are included in CALVIN (e.g. pumping and water treatment costs). Other costs (e.g. management costs, maintenance of conveyance infrastructure) and fixed capital costs are not included.

BASE CASE

To provide a common benchmark for comparison, model runs will be compared to a base case. The choice for this base case is 2020 level demands but with existing facilities plus those that will definitely be in-place by the year 2020. This latter includes facilities for which construction has already begun or for which detailed engineering plans exist and financing obtained. For the base case, CALVIN is constrained to mimic current projected operations. Water is allocated to users according to current contractual agreements and water rights. Deficiencies are imposed in dry years in line with current projected estimates. The operation of surface reservoirs will be constrained to follow projected operations. The cycle of groundwater pumping and recharge will be similarly constrained to reflect current projected estimates of groundwater extraction.

ALTERNATE MODEL RUNS

Table 7-1 lays out the strategy for making and comparing model runs. A total of 13 basic model runs are envisioned, representing different combinations of policy and infrastructure options. Moving from column to column, left to right, represents the addition of new facilities. Moving from row to row represents different policy options. The first row represents water allocation in an idealized water market. The last row represents current regulation and practices. It is interesting to note that from a modeling perspective, policy 1 is the easiest to model. No operational or regulatory constraints are imposed on the model other than environmental requirements. Moving down the table, the model becomes increasingly complex as additional layers of constraints are added reflecting the complexity of current operating rules.

Table 7-1. System Alternatives

	Facility Options			
Policy Options	Projected (a)	Additional Storage (b)	Isolated Facility (c)	(a), (b), & (c)
1. Price Allocation	1a	1b	1c	1d
2. Minimum Deliveries	2a	2b	2c	2d
3. Fixed Operation & Min Deliveries	3a	3b	3c	3d
4. Fixed Operations & Deliveries (Base Case)	4a	-	-	-

New and Expanded Facilities

Four scenarios for new facilities will be investigated:

- 2020 'existing' facilities,
- additional storage and expanded conveyance,
- isolated facility, and
- additional storage, expanded conveyance, and an isolated facility

The specific locations and capacities for expanded storage and conveyance facilities will be determined at a future time.

Policy Options

The four policy options are depicted in Figures 7-1 to 7-4.

Policy 1: Price Allocation

Policy 1 represents allocation according to price (Figure 7-1). Operation of the infrastructure is constrained only by the physical capacities of the system and by environmental demands. This reflects a free market operation or the implementation of an unregulated water market. Within the limits of the system and environmental constraints, water is transferred and allocated to users with the highest willingness-to-pay. The model 'assumes' that users will trade water driven by their temporal differences in the valuation of water. Under this operation it is expected that there will be a general reallocation away from low value agriculture to urban demand and high value agriculture. Urban water supply reliability should improve while agriculture will suffer more 'shortages' during dry years. This option also makes the most economically beneficial and flexible use of the operations of storage and conveyance facilities.

This policy option should produce the highest economic benefits (least costs). It is not advocated that this policy be implemented. Rather it provides an upper bound to the economic benefits of restructuring water operations.

Policy 2: Water Market with Minimum Deliveries

Policy 2 represents a regulated market. As for policy 1, there are environmental and physical constraints. However, an additional set of constraints is introduced to ensure minimum deliveries to urban and agricultural users (Figure 7-2). Minimum deliveries correspond to existing contractual agreements and water rights but with deficiencies imposed in dry years. These deficiencies will be based on projected deficiencies calculated by detailed simulation models (DWRSIM, PROSIM, SANJASM, and CVGSM). Operation of the surface reservoir and groundwater system will be unconstrained. Under policy option 2, CALVIN will be able to store and allocate any 'surplus' water to the highest economic use. Surplus water might be obtained through better system operation, conjunctive use or the use of expanded or new facilities.

This policy option allows CALVIN the chance of 'doing better' than current project operation and deliveries. It should point to promising new and innovative ways in operating reservoirs as one integrated supply system rather than a series of separate project and non-project facilities.

Policy 3: Water Market with Minimum Deliveries and Constrained Operations

A further layer of constraints is added under policy 3 (Figure 7-3). Existing surface water reservoirs are operated in accordance with current projected operating rules. Monthly reservoir target levels and annual carry-over storages are met where possible. Existing rules governing the sequence of drawdown and refill of project (CVP and SWP) reservoirs are followed. In addition the projected pattern of groundwater extraction is enforced. Policy option 3 still allows CALVIN to allocate surplus water to the highest economic value. However it is expected that without new facilities the amount of surplus water will be minimal. This policy enforces current projected operations under which water in all but wet years is fully allocated.

The purpose of this option is to evaluate the benefits of new facilities or expanded capabilities under the current system operation. It will be of particular use to identify who gains from specific infrastructure developments and: (a) whether there is sufficient economic benefits to justify system expansion; (b) allocation of project costs in the case of public financing of new facilities; (c) to measure whether benefits are sufficient to attract private investment.

Figure 7-1. Policy 1: Price Allocation

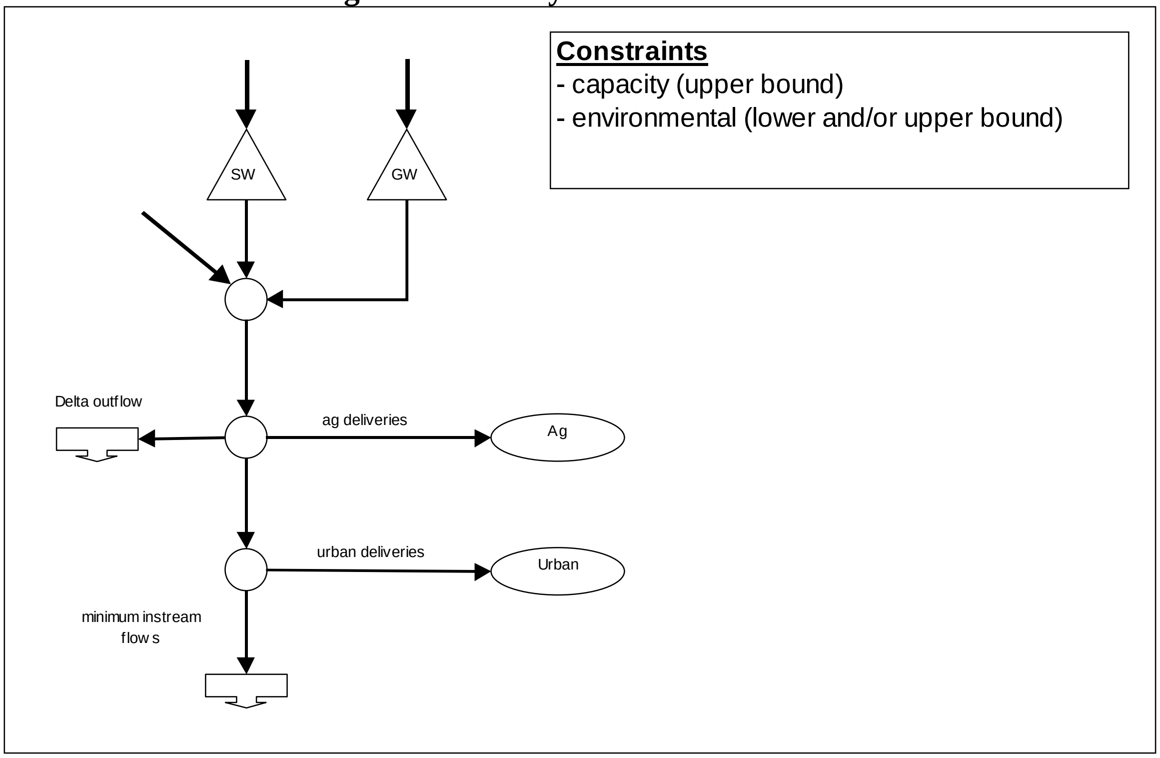


Figure 7-2. Policy 2: Minimum Deliveries

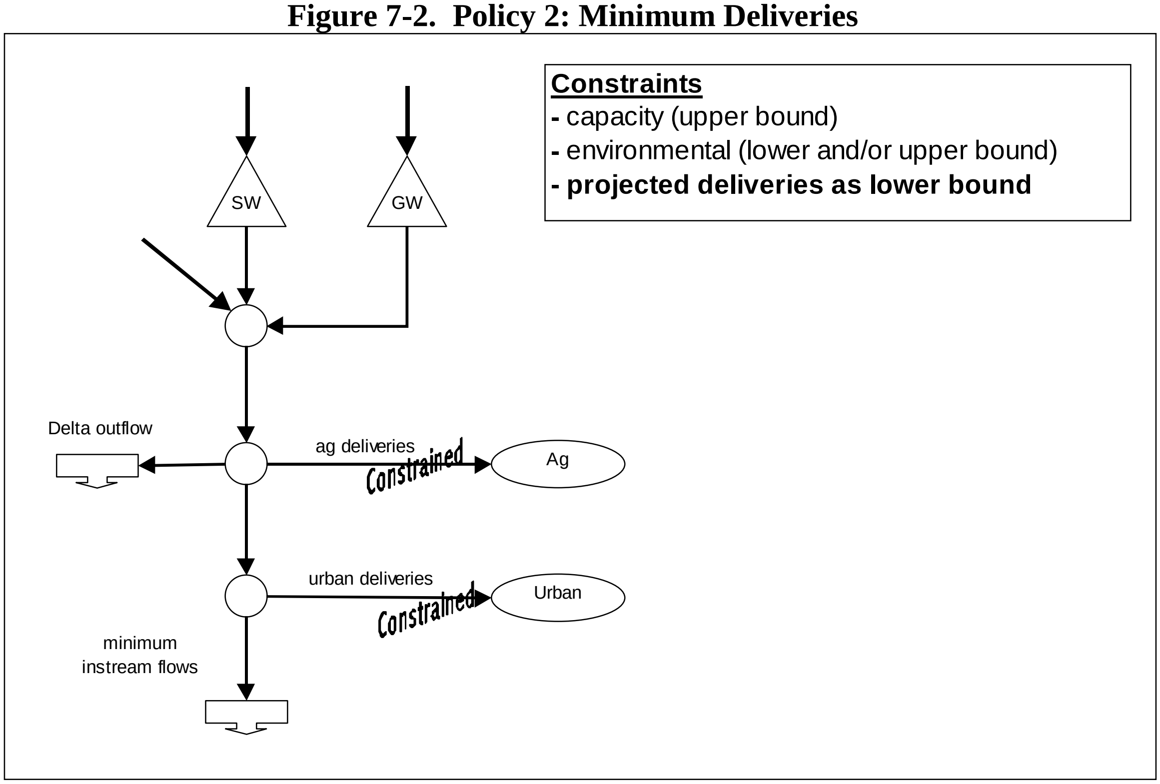


Figure 7-3. Policy 3: Fixed Operations and Minimum Deliveries

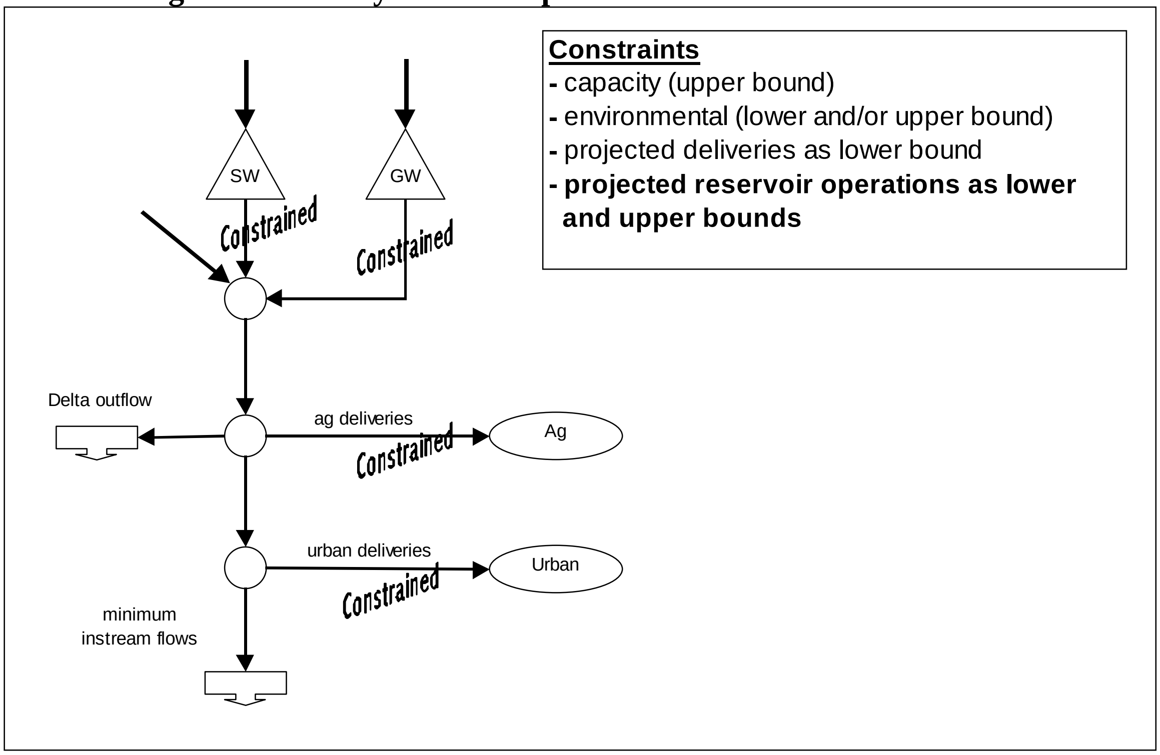
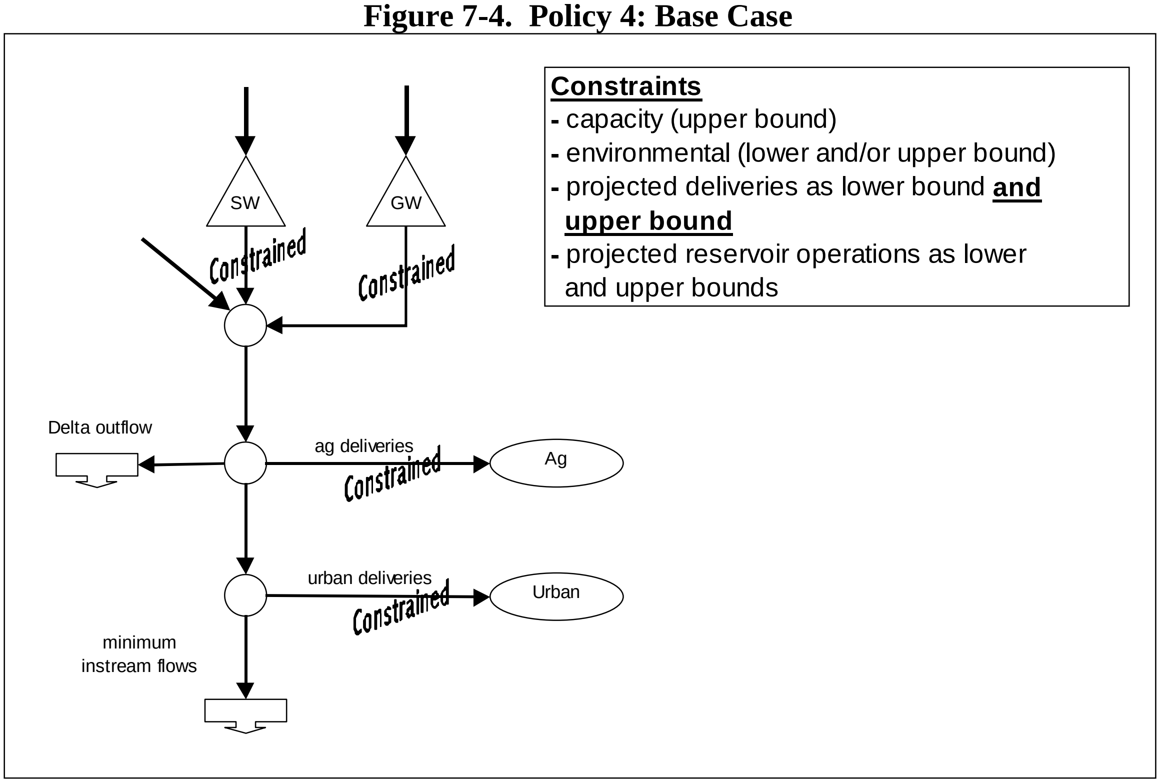


Figure 7-4. Policy 4: Base Case



Policy 4: Current Operations and Allocation Policies

As mentioned above policy 4, run 4(a), represents the base case scenario for comparison of economic benefits predicted for other alternatives. Under this policy, CALVIN is constrained so as to equal the currently projected deliveries of detailed simulation models and to exactly match their reservoir operation. Deliveries and storages are now constrained as both lower and upper bounds. CALVIN is so fully constrained that it cannot improve on current projected operations.

Economic benefits predicted from CALVIN for the CVP/SWP should match those that could be obtained by postprocessing results from DWRSIM. Modeling of this policy will also provide cross-model validation of the model and inputs by comparison with DWRSIM results (run 514).

Demand Management

CALVIN seeks to manage demand in an economically optimal manner. Demand management is handled implicitly by CALVIN through the use of economic value functions. Implicit in the agricultural value functions is the move to less water demanding and higher value crops and acreage reduction in response to water scarcity and high water prices. Similarly the urban value functions reflect the implementation of short-term conservation measures in response to water high water prices.

To examine the economic desirability of capital infrastructure changes in irrigation or urban water use technologies would require additional urban and agricultural economic modeling to modify CALVIN's economic value functions, with separate incorporation of fixed capital costs, much as how new facilities are handled.

MEASURES OF PERFORMANCE

The performance of an alternative can be assessed in several ways using CALVIN's outputs. Some of these are described below.

Physical

Reliability of supply is the key indicator. The time-series of water deliveries to urban and agricultural users will be compared with the input demands and expresses as an exceedance plot. This shows the percentage of years/months that demand is met and for the case of shortages the percentage of demand that is met.

Environmental

Environmental flow requirements are constraints and so are automatically satisfied by CALVIN. However, many environmentalists regard regulatory instream flows as inadequate or as minimums. Additional flows are desirable. Although impossible to quantify the absolute benefits, stream flows can be compared between runs and expressed in the form of minimums, averages, standard deviations and quartiles.

Environmental needs and regulations are pre-processed and are always represented in the model as a time-series of flows or storages. Postprocessing of results is required to check whether the original environmental objectives have been violated. This is particularly true for the Delta outflow requirements.

Economic

Economic benefits are derived from increased supplies, improved supply reliability, and, in some cases, quality. Scarcity provides incentives to change infrastructure and system operation. From the combination of the input value functions and the time-series of deliveries, the economic benefits of different model runs can be evaluated and broken down by sector and by region. The agricultural deliveries will be post-processed through SWAP to: (a) confirm that CALVIN is correctly allocating water across months; (b) to obtain a breakdown of the crop mix.

Financial

The ability of any new infrastructure to attract private investment capital may be crucial for the expansion of the current system. Output from CALVIN includes a time-series of shadow values on storage and flow capacities. These indicate where, when, and by how much a unit increase in capacity would result in economic benefits. Comparison of two model runs with different system capacities is required to quantify the total overall benefits. 'Winners' from increased capacity can be identified and the increase in consumer surplus (urban sector) or revenues (agricultural sector) can be used to create a time-series and statistical distribution of expected revenues. As an investment this can be compared to other types of investments with risk and fluctuating returns.

The refinancing of existing public facilities can also be examined. For example, the capacity of the California Aqueduct may limit water transfers to the south. The state recovers the canal's capital cost from state water contractors via a combination of charges that are a function of water deliveries and contractors entitlements. The wheeling of water for third parties through the aqueduct as part of a regulated water market has financial implications for both the state and the state water contractors.

CONCLUSIONS

By comparing various CALVIN model runs, the relative economic performance of particular facility and policy alternatives can be assessed. These relative alternative assessments are in addition to the information gained from a single run, as discussed in the next chapter.