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California State Senate

MICHAEL J. MACHADO
SENATOR, FIFTH DISTRICT

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October 30, 2002

Director Tom Hannigan
Department of Water Resources
1416 Ninth Street
Sacramento, CA 95814

Dear Director Hannigan:

I have asked the California Research Bureau to comment on the Draft State Water Project (SWP) Supply Reliability report because questions are being raised by many in the water community regarding the conclusions of the report. With outstanding questions still not addressed, it will be difficult to make progress on many of the critical water issues facing the state.

- Local development could be hampered if, when complying with SB 221 (Kuehl) and SB 610 (Costa) or California's Environmental Quality Act (CEQA), there are significant disputes over current and future water supplies.

- Conclusions of CalFed's Integrated Storage Investigation (ISI) will be suspect given that the same model is used in both the ISI and the SWP Reliability reports.

- Future statewide bonds for increasing water supply will be in jeopardy, if opponents can credibly challenge the underlying analysis.

It is critical that the final SWP Reliability report has widespread support. Until the Department of Water Resources (DWR) resolves concerns raised, the report seems premature and could lead to additional water challenges in the future.

Sincerely,

MICHAEL J. MACHADO
Senator, Fifth District

MJM:bw

Cc: Jonas Minton, Department of Water Resources
Lucinda Chipponeri, Department of Water Resources

Comments on the Department of Water Resources' Draft State Water Project Supply Reliability Report

Dennis O'Connor, Assistant Director
California Research Bureau

November 1, 2002

The Department should be commended for attempting to accurately describe the State Water Project's (SWP) supply reliability. If Californians are to plan effectively for their water future, it is important to that we describe our water supply reliability accurately and thereby avoid basing decisions on assumptions about water that exists only on paper. However, as these comments show, the Department's attempt so far falls short of this goal.

Senator Mike Machado asked that the California Research Bureau comment on the Draft State Water Project Supply Reliability Report (Report). He did so because there appears to be a lack of widespread confidence in the conclusions of the report. In particular, many think the modeling behind the report overstates the supply reliability of the SWP. If this is true, then instead of a "paper water" problem, we might have a "cyber water" problem.

What Does The Report Say?

The purpose of the report is to "assist the contractors of the State Water Project in the assessment of the adequacy of the SWP component of their overall water supplies."* It does so by constructing *delivery probability* charts for the SWP. These charts show the probability of the SWP delivering from the Sacramento-San Joaquin Delta a given quantity of water for a given year under a given set of conditions.

The Department calculated delivery probability charts for two years, 2001 and 2021. For both years, the Department assumed the current water facilities continue to operate as they do now. That is, no new water facilities would be added or removed, there would be no changes in operating rules or regulatory restrictions, etc. The only thing that would change between the two years is the "level of development"; that is, the amount of water used upstream of the Delta. That amount changes between 2001 and 2021 based on assumptions about future population growth and development. For both years, the Department assumes "variable demand"; that is, contractors will change the amount of water they request based on how wet or dry the year is. In addition, the Department created a delivery probability chart for 2021 that assumed all contractors requested their full "Table A" or contractual amount. (Table A amounts were formerly known as entitlements.)

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* California Department of Water Resources. *The State Water Project Delivery Reliability Report,* Draft. (Sacramento: The Department), August 2002. p. iii

In addition to Table A amounts, the Department also calculated delivery probabilities for Article 21 water. Article 21 water, also known as surplus water, refers to water that is available once all SWP demands are met. This means the reservoirs are full, all Table A requests are met, and there is still water legally available to export from the Delta.

The result of all this analysis was a series of delivery probability charts. The figure below shows the delivery probability chart for the 2001 level of development. The chart shows Table A delivery on the left axis, and the corresponding percent of full Table A contractual amounts on the right. The bottom axis shows the percent of time one would expect to receive a given quantity of water. The chart shows that for the 2001 level of development, the SWP would be able to deliver at least 804 thousand acre-feet (taf) of water 100 percent of the time – 804 taf is the minimum the SWP would ever deliver. The most the SWP would be able to deliver would be 3,845 taf. The median delivery is 3,297 taf. As the chart shows, the median delivery is the amount of water that corresponds to the 50 percent probability level. This means that for the 2001 level of development, half the time the SWP would deliver more than 3,297 taf, and half the time the SWP would deliver less.

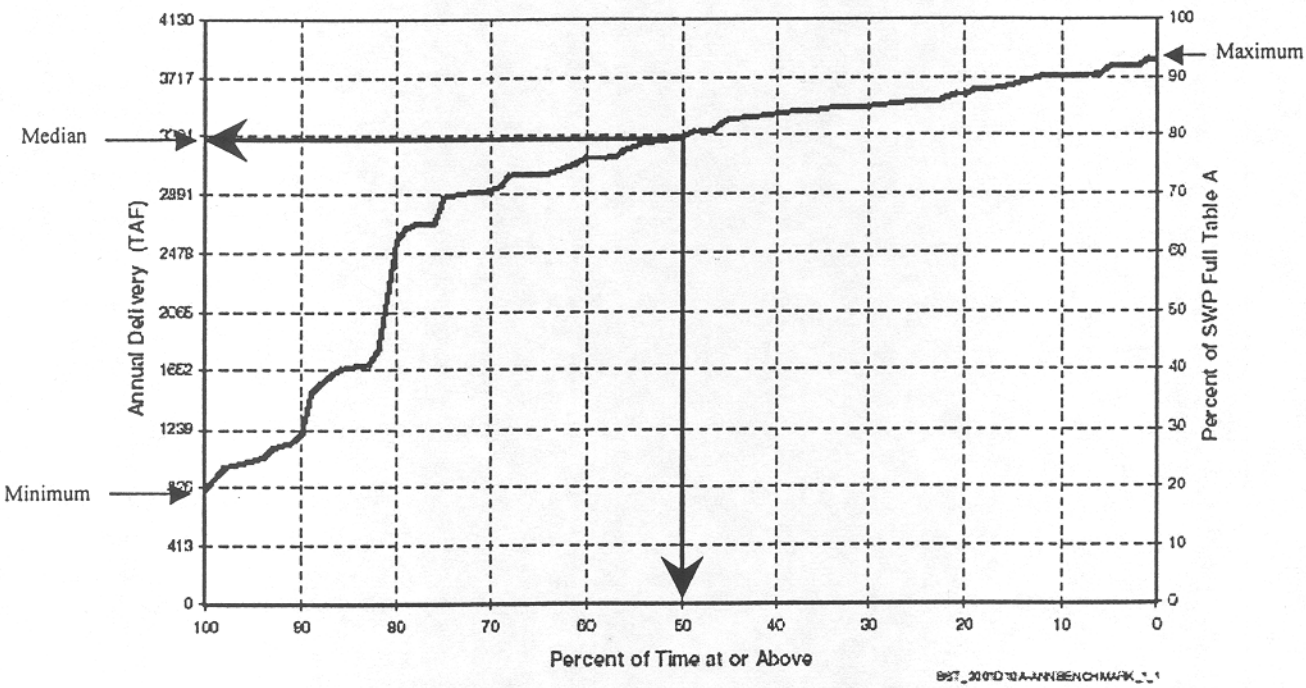
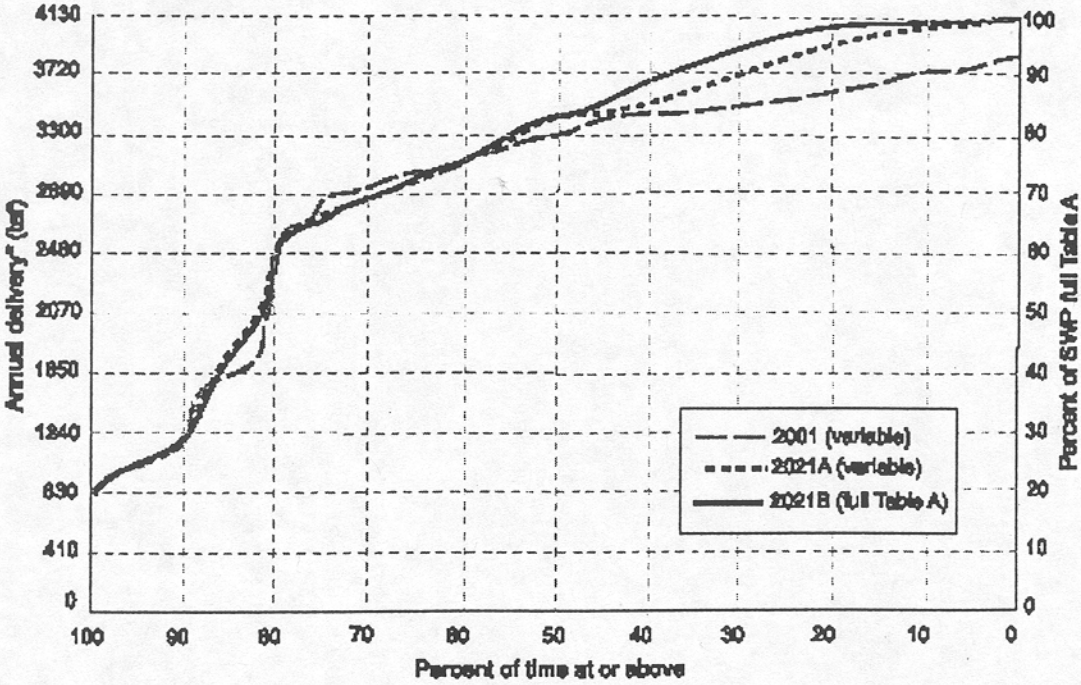


Figure B-1 Study 2001 SWP Delta delivery reliability

Similar charts were created for 2021 level of demand with contractor demands that vary with the weather and for 2021 with full Table A demand.



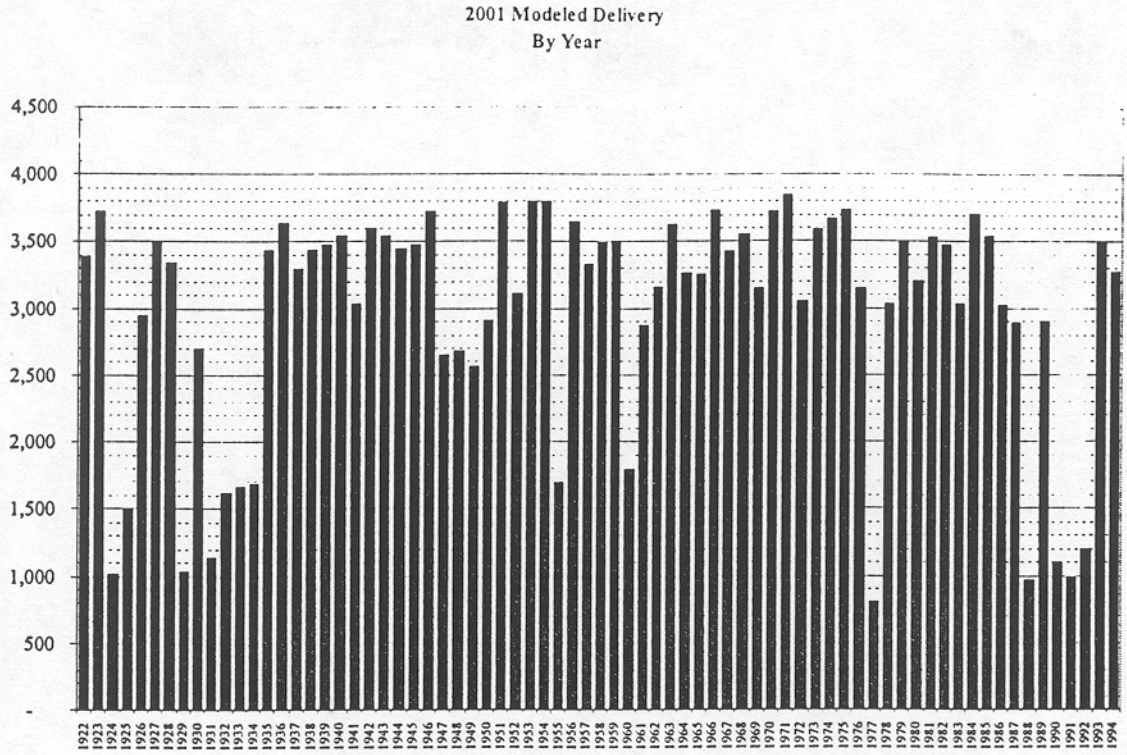
* Annual delivery rounded to nearest 10,000 acre-feet

Figure 1 SWP Delta delivery probability (Table A)

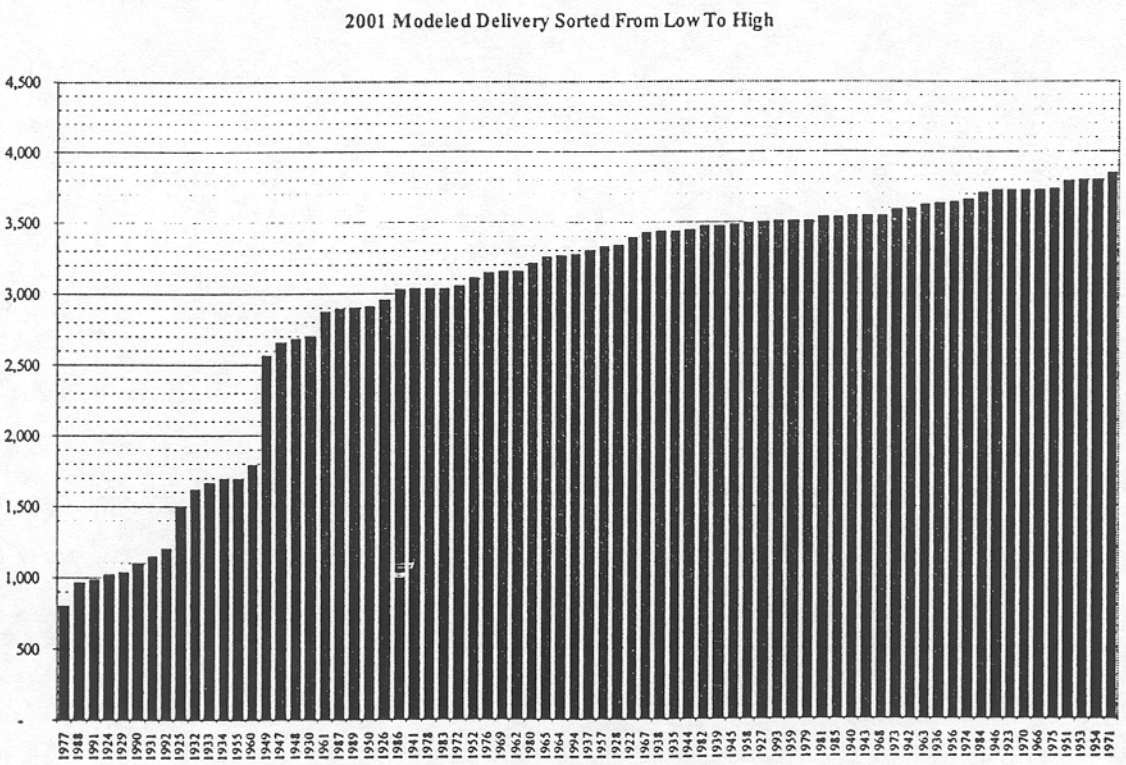
How Did The Department Estimate The Delivery Probabilities?

To estimate the delivery probabilities, the Department used a model called Calsim II. Calsim II is a complex linear programming model that attempts to mathematically simulate the operations of the SWP and the Central Valley project. To do this, Calsim II has a large set of equations that describe how all the various rivers, dams, canals, diversion points, discharge points, etc. all relate to each other. It has another large set of equations that describe the rules for operating the various water facilities – when to create flood control storage, when to reduce delta exports to meet water quality regulations, etc. Calsim II then associates with these equations data that describe the particular point in time under consideration. For the draft reliability report, those data describe the level of development in 2001 and 2021.

To develop the delivery probabilities, Calsim II is then asked the following question. Assuming all of these relations and conditions for 2001 stay the same, how much water would be available for export from the Delta if, instead of 2001's weather pattern, we had 1922's weather pattern instead. Then, given how full the reservoirs would have ended up after 1922's weather pattern, what would happen if we then we had 1923's weather pattern, 1924's weather, and so on. The following chart shows the Calsim II results for 2001 level of development.



The basis for the delivery probability chart becomes clear when these data are sorted from low to high.



Why Do People Question the Results?

People have raised a litany of concerns with the results. Some of these concerns are more valid than others. The major concerns seem to be:

- Recent deliveries were lower than the modeled 2001 conditions.
- 2021 does not seem to reflect any growth in upstream consumptive use.
- Calsim II has not been calibrated, tested, or otherwise verified.
- The results appear inconsistent with previous estimates and models.
- Calsim II is not being used as designed.

Each of these concerns is discussed in turn, with a short assessment of their legitimacy.

Recent deliveries were lower than the modeled 2001 conditions.
Chart 1 (attached) shows historic Table A deliveries along with the modeled maximum, minimum, and median level for 2001 conditions. Recall that under 2001 conditions, half the time one would expect to receive more than the median level, half the time less. As Chart 1 shows, not once has the SWP delivered Table A water equal to the median rate. So, many think Calsim II over estimates the SWP's delivery reliability.

Part of the problem is that Calsim II calculates Table A deliveries slightly differently from those reported in Bulletin 132. For example, Calsim II counts water contractors carryover in the year it is created, not the year it is delivered. That is, Calsim delivers water whenever it has the capacity, with no allowance for a contractor's desire to carry water over to the next year. The difference between actual Table A deliveries as reported in Bulletin 132 and as calculated in Calsim II is shown in Chart 2.

Chart 3 shows the actual Table A deliveries, adjusted for how Calsim II treats carryover, along with the modeled maximum, minimum, and median level for 2001 conditions. Once placed on an apples-to-apples basis, the adjusted Table A deliveries still look low compared to the modeled 2001 delivery reliability. Only once do deliveries reach the median rate – the amount the model says would be deliver half the time. And as shown in Chart 4, the picture doesn't change much when Article 21 (surplus) water is included. Recent experience seems lower than modeled 2001 conditions. So, Calsim II continues to look like it overstates the delivery reliability of the SWP.

A strong counter to the argument that Calsim II exaggerates the SWP's reliability would be that the reason the SWP hasn't delivered that much water in the past is because the contractors haven't asked for that much water. However, this doesn't seem to be the case. Chart 5 shows Actual Table A deliveries and contractors requested delivery. As the chart shows, on 9 occasions requests have been higher than the median rate, only once has the median rate been met. In fact, only once in the last 12 years has the SWP been able to deliver 95 percent or more of contractor requests. Again, Calsim II looks like it over estimates SWP reliability.

Nor does water year type seem to explain the discrepancy. Chart 6 is the same as Chart 5, except the water year type (Sacramento River Index) is shown above each

delivery amount. It shows, for example, that 1998 was a wet year, contractors requests were greater than the median rate, yet contractors received only half of their requested amount (as defined by Calsim II).

What the chart does not show, is that because of the heavy snow pack and spring runoff in 1998, the contractors did not want all of the water they had initially requested. They cut their demand, including carryover water, to just under 1.7 million acre feet (maf). However, the modeling didn't foresee this possibility. The modeling assumptions varied demand between 3.0 and 4.1 maf based on weather. The 3.0 maf demand used in the wettest years was well above the 1.7 maf ultimately demanded by the contractors in 1998. This suggests that the modeling assumptions might be part of the reason Calsim II seems to overstate delivery reliability.

While many try to compare the modeled 2001 reliability against historic SWP operations, it is not really appropriate for much of the period. As previously noted, Calsim II assumes there are no changes from 2001 in the physical and operational aspects of the SWP. Yet in the early history of the SWP, many facilities were not constructed. For example, the big pumps at Edmonston Pumping Plant didn't start pushing water over the Tehachapis until 1971. Also, Contractors' contractual claims for delivery as reflected in Table A were greatly diminished in the early years – it wasn't until 1990 that Table A amounts exceeded 4.0 maf. And, regulatory rules governing the Sacramento-San Joaquin Delta have also changed over the years. The current governing rules, D-1641, weren't issued until 1995. Consequently, comparing modeled 2001 reliability against actual deliveries is somewhat misleading much beyond the last few years.

So, lets look at recent years. Following the notion of water year further, Chart 7 is the 2001 modeled delivery, sorted by water year type (Sacramento River Index). This way one can compare recent years to the appropriate water year type reliability. The first thing one notices is that the median level for below normal years is *higher* than the median level for above normal years and is nearly the same as for wet years. Common sense would suggest that the median level in below normal years would be *less* than the level for above normal years. This suggests something odd is going on within Calsim II.

Water year 2001 was classified "dry" and contractors requested Table A deliveries of over 4.1 maf. Chart 8 shows actual 2001 Table A deliveries (adjusted) compared to modeled 2001 dry year reliability. It shows that 2001 deliveries were less than the least amount Calsim II would say would ever be delivered in a dry year. However, one would expect 2001 deliveries to be greater than the lowest dry year. 2001 was not the driest dry year – 1932 was. Also, 2001 followed an above average year, which itself followed five consecutive wet years. Consequently, the beginning storage in 2001 ought to have been much higher than in 1925, which followed the driest year modeled, or 1932, which followed a 3 year period of dry and critically dry years. This is further evidence that Calsim II overstates delivery reliability.

Water year 2000 was classified as "above normal." Chart 9 shows actual 2000 Table A deliveries compared to modeled 2000 above normal year reliability. It shows that 2000

deliveries were above the median for above normal years. This is seems reasonable, and appears to be the exception to the rule.

Water years 1998 and 1999 were classified "wet" and in both years contractors requested more than 3.3 maf. As Chart 10 shows, actual 1998 and 1999 Table A deliveries were again less than the least amount Calsim II would say would ever be delivered in a wet year. In fact, 1998 deliveries were 45 percent less than the lowest modeled delivery. In both years, because of a high snow pack and runoff, contractors did not want the full amount of water they initially requested. However, as noted above, the assumptions behind Calsim II did not consider that contactors might reduce their demand below 3.0 maf. This reinforces the notion that the modeling assumptions might be part of the reason Calsim II seems to overstate delivery reliability

In summary, while a strict comparison of historic Table A deliveries to modeled 2001 delivery reliability suggests Calsim II over estimates the SWP's delivery reliability, such a comparison is misleading. Part of problem is that Bulletin 132 and Calsim II calculate Table A deliveries slightly differently. Another problem is that Calsim II assumes there are no changes from 2001 in the physical and operational aspects of the SWP. Yet as recently as 1995, the Delta's regulatory operations were much different.

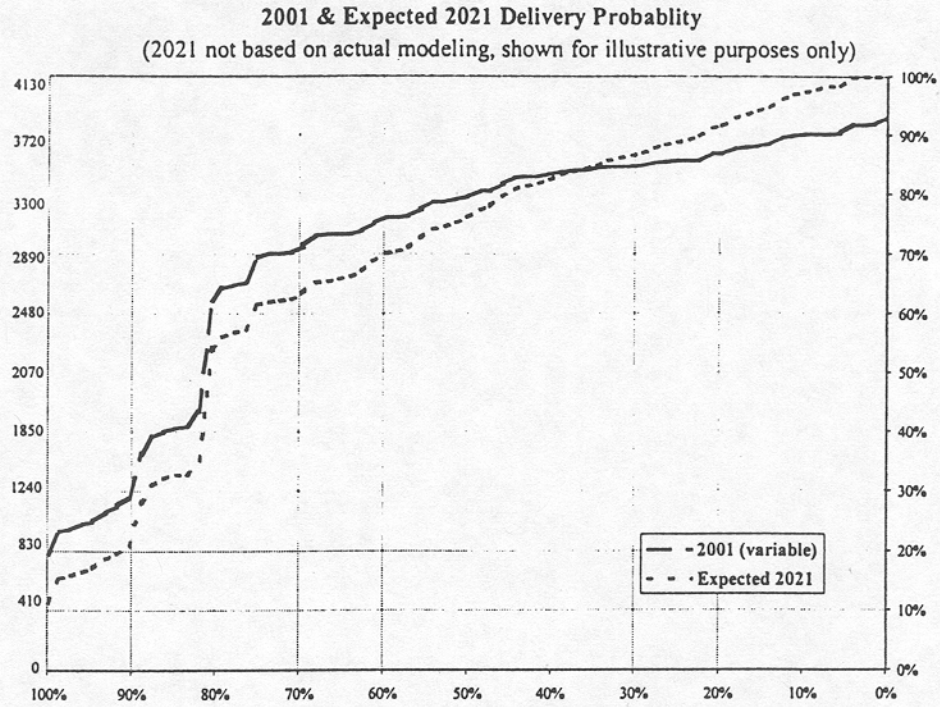
Nonetheless, there is still much evidence that suggests there is something wrong with the Calsim II results. For example, the median level for below normal years being *higher* than the median level for above normal years and being nearly the same as for wet years is quite curious.

Moreover, much of the evidence that suggests there is something wrong with the Calsim II results indicate that the modeled 2001 results overstate SWP delivery reliability.

- Only once in the last 12 years has the SWP been able to deliver 95 percent or more of contractor requests.
- The 3.0 maf contractor demand used in the wettest years was well above the 1.7 maf ultimately demanded by the contractors in 1998.
- 2001 deliveries were less than the least amount Calsim II would say would ever be delivered in a dry year, despite evidence that it should not have been.

All this implies there is either a problem with Calsim II, its assumptions, or both.

2021 does not seem to reflect any growth in upstream consumptive use.
The draft report shows SWP Delta delivery probabilities under 2001 and 2021 levels of development. Presuming that upstream development – and hence consumptive water use – will be greater in 2021 than in 2001, one would expect that during periods of water shortage, less water would be available for export in 2021 than in 2001. This is illustrated below.



However, the chart below from the report shows, for much of the time, the modeling results show *more* water being delivered in 2021 than in 2001. That might make sense during wet periods where the supply constraint would be small, such as when deliveries are at the 0-30 percent level. However, it is particularly troubling in dry periods when water supplies would be particularly tight, such as the 85-80 percent level. So again, the model appears to overstate SWP delivery reliability.

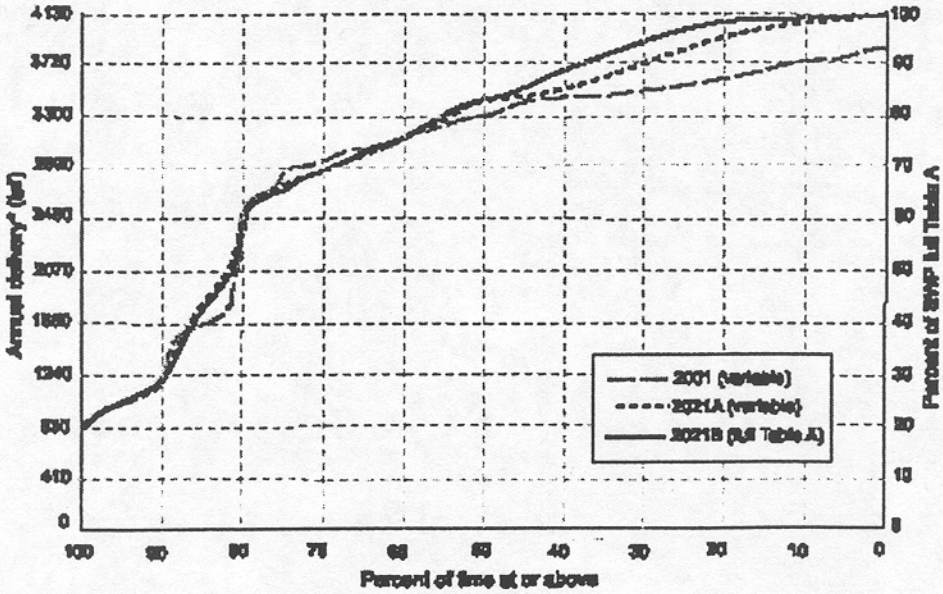


Figure 1 SWP Delta delivery probability (Table A)

Calsim II has not been calibrated, tested, or otherwise verified.
The Department is releasing this report based on results of a highly complex model that has not been calibrated, tested, or otherwise verified. Calibration is a systematic process of adjusting a model to ensure that the model output accurately matches actual experience. Such adjustments might have to do with changing assumed channel capacity, maximum or minimum water flow rates, reservoir operations, etc. When a model has not been calibrated or otherwise tested or verified, one cannot be sure that the model accurately reflects reality.

This lack of calibration or testing is especially troubling given the many changes made between this model and its predecessor.

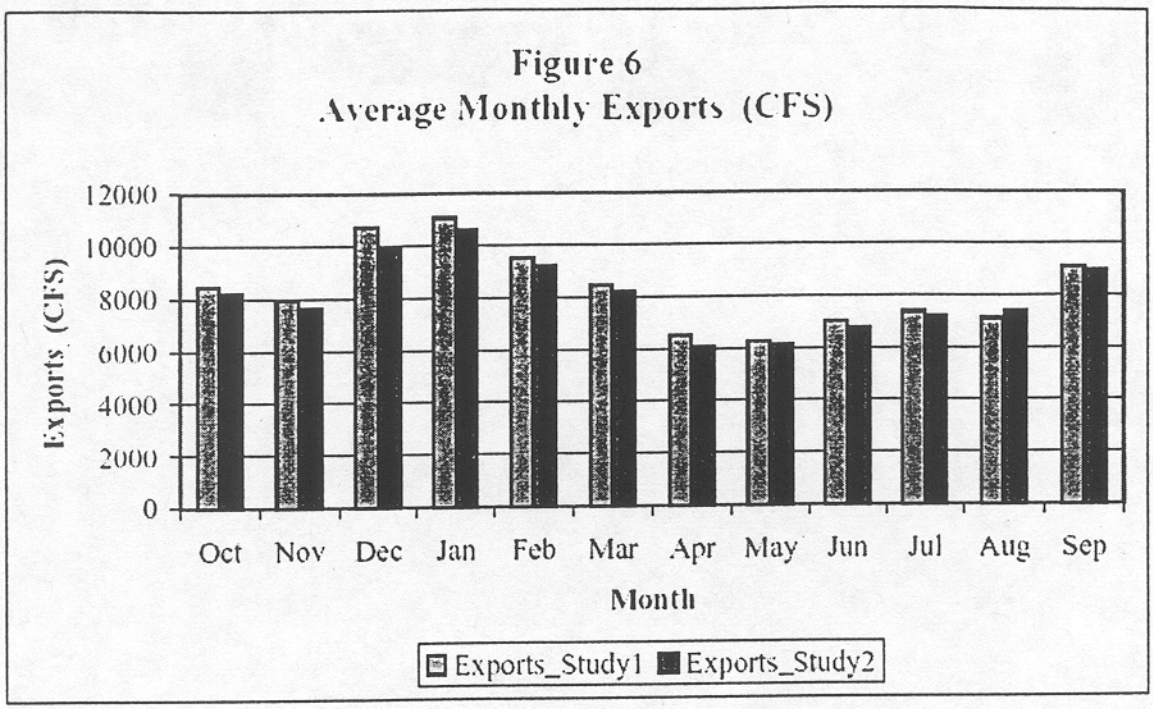
These changes include:

- New logic for determining deliveries to north-of-Delta and south-of-Delta CVP and south-of-Delta SWP contractors;
- New procedures for dynamic modeling of CVPIA 3406(b)(2) water and the Environmental Water Account (EWA);
- Addition of numerous surface streams and control points; and
- Incorporating groundwater into the modeling.

The interaction of groundwater into the modeling is a particular concern. The California Water Plan Update Modeling Workgroup meet last year to get an update on Calsim II. At the meeting, a Department staff person commented on the tendency for Calsim II to pump groundwater without regard to sustainable yield or capacity of the aquifer. That is, Calsim II tended to assume that upstream water users would pump groundwater beyond all practical limits. This might explain why, as discussed in the previous section, additional upstream development in 2021 did not affect dry year delivery reliability – the model might have assumed that more groundwater would be pumped to meet any assumed additional upstream demand. This is another reason why Calsim II appears to overstate SWP delivery reliability.

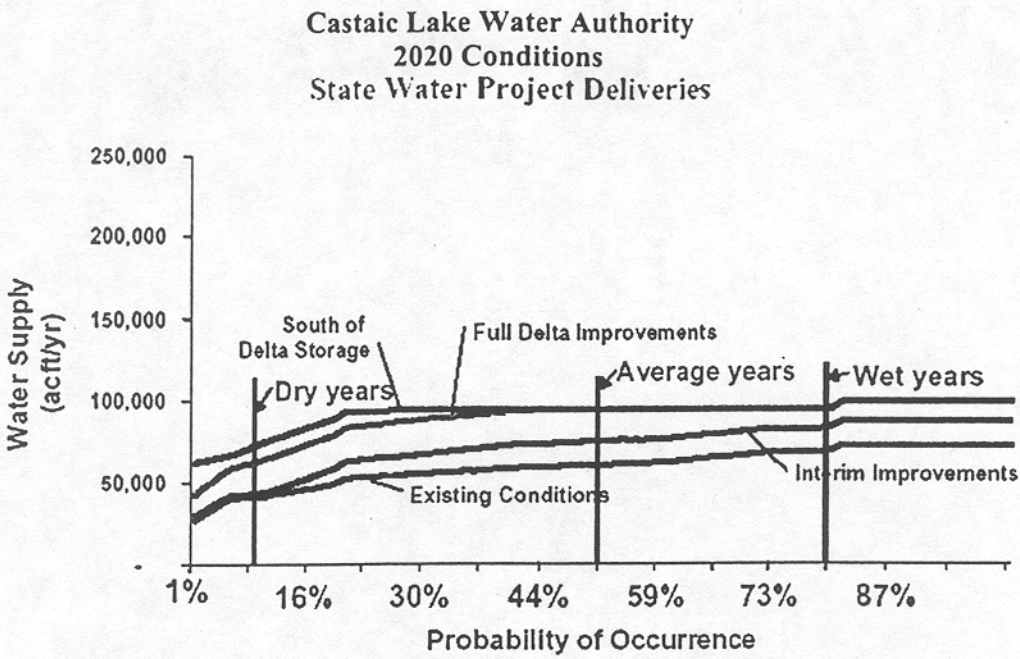
The results appear inconsistent with previous estimates and models.
The monthly timesteps used by Calsim II overestimates delta export capacity when compared to the daily timesteps used in DWR Delta Simulation Model (DWRDSM2). As noted in the In-Delta Storage Program's *Draft Report on Operation Studies*.

The daily fluctuations of inflow above and below the monthly mean cause a diversion pattern that reduces the exports from the Delta as compared to those achieved in the monthly model. This phenomenon is shown in Figure 6, where the monthly average amounts exported by the daily model are shown to be consistently lower than those in the monthly model, except for August. The lower exports inevitably impact on the annual deliveries.



In Figure 6, reproduced above, the monthly Calsim II results are labeled Exports_Study1 and are the left bar for each month. The daily model results are labeled Exprts_Study2 and are the right bar for each month. The models clearly disagree on export capacity. However, we do not know which model more closely simulates actual export capacity.

Calsim II also shows higher delta export capacity when compared to the results of DWRSIM, the predecessor to Calsim II. Castaic Lake Water Agency, in developing their 2000 Urban Water Management Plan, used DWRSIM, to estimate their SWP delivery reliability. Their analysis showed that under 2020 conditions, with no changes to existing facilities or operating rules, the maximum delivery they could expect would be just over 70% of their maximum Table A deliveries. This is significantly different from the Calsim II results, which show they should expect to receive 100 percent of their maximum Table A deliveries nearly 10 percent of the time. Again, the models clearly disagree on export capacity. However, once again we do not know which model more closely simulates actual export capacity.



Castaic Lake Water Agency. *2000 Urban Water Management Plan*. 2000. p. 2-12.

Calsim II is not being used as designed.

Calsim II was designed to answer the following type of question. Given that we have a problem with something, such as meeting delta water quality requirements, would making a specific change to the system, such as adding a reservoir, make the problem better or worse? To answer the question, Calsim II is first set up and run to representing the way the system is currently. This is referred to as the "base" simulation. Then the model is adjusted to represent the specific change under consideration. This is called the "with project" simulation. Then the results of the two simulations are compared to see if the proposed change makes thing better or worse.

Calsim II was not designed to be used to establish absolute levels of exports, as it is in this report. As noted in the *Benchmark Studies Assumptions*:

It is intended, that CALSIM II be used in a comparative mode. The results from a "With Project" alternative simulation are compared to the results of a "base" simulation, to determine the incremental effects, of a project. The results from a single simulation may not necessarily represent the exact operations for a specific month or year, but should reflect long-term trends. – Benchmark Studies Assumptions, September 30, 2002

When used in the comparative mode, it is at least possible that any systematic problem with the model would "cancel each other out." This is not the case when used to establish absolute levels of exports, as it was in the draft reliability report.

People are understandably concerned whenever a model is used in a way different from than for which it was designed. This is especially true when the different use of the model has not been rigorously evaluated. Without testing or otherwise verifying Calsim II, it is simply not possible to know whether or not the model's results are reliable when Calsim II is used as it is in the draft reliability report.

Other Concerns

The proceeding are the most frequently mentioned concerns with the draft report. However, there are many others. These include:

- The "level of development" estimate was based on the oft-criticized Bulletin 160-98. One of the criticisms about Bulletin 160-98 was that it overestimated urban water demand, including areas upstream of the Delta. Because of these criticisms, the next edition of Bulletin 160 will use a different process for estimating urban water demand. Consequently, the concerns about using the Bulletin 160-98 estimates seem legitimate, though the effect on delivery reliability is uncertain.

- One cannot evaluate the reasonability of SWP delta exports without also looking at the CVP exports. These estimates are not reported and the US Bureau of Reclamation has not done a similar exercise. It is possible that one reason SWP delivery reliability seems high is that the model essentially took water from the CVP and delivered it to SWP. Without seeing the modeled exports for both projects, one simply cannot know.

- The Department's public explanations for why the model is reliable rely solely on the modeling analysis. There has been no outside corroboration of the model results. This is an issue of credibility, and again seems legitimate.

- Calsim II assumes that the system is run "by the book." However, there are numerous examples where the system was not run "by the book" with often significant consequences. For example, 1990 operating decisions "bet" that there would not be another critically dry year in 1991. This lead to disastrous conditions in 1991. While this is a legitimate criticism, it is not certain that the modeling would require some correction. It might be that the operators simply need follow the operating rules to more closely.

- Calsim II does not model curtailments at pumps for exceeding the take limits of endangered species. Yet this occurs somewhat frequently. This might be another reason why delivery reliability appears high.

- Calsim II assumes water delivered any time of year is useful to all contractors. This might be true for Metropolitan Water District of Southern California and the Kern County Water Authority as they have own storage options. This is not true for other contractors such as Santa Barbara County. Again, this might be part of the reason why the modeled delivery reliability seems to have been overestimated.

- Legislature has had credible testimony that the historic weather pattern is no longer a reliable indicator of the future. Yet, the simulation was based entirely on historic hydrology. A shift from snow to more rain predicted by climatologists would have big consequences for delta exports. However, it is not clear that such effects would be noticeable by 2021.

- Recent years are not included in analysis – the simulation ignores 1995-2001. While it might be unrealistic to expect all the data necessary for including 2000 or 2001 to been developed yet, it does seem reasonable to expect data for the 90s to be included.

Additional Issues That Cause Some Concern

- At some of the public briefings, the Department's explanations for increased reliability in future the occasionally referred to actions or programs not included in modeling; such as increase regulatory limits on exports or new facilities. Yet, such changes were not a part of the analysis, so those changes could not be part of the reason for higher delivery reliability.

- Much of the data are of poor quality – especially for groundwater effects. If you don't think the model inputs are accurate, it is difficult to accept that the model outputs are accurate.

- Calsim II is a linear model used to simulate what looks to be a non-linear system. This suggests the model is misspecified, with difficult to predict consequences.

- Department did not take testimony in public – public cannot hear others' concerns about the report before they submit their comments.

- Typos – Table B-3, column labeled "model variable demand" shows average 3712. Average of column is in fact 3709. All the data in the report need double checking.

Why is this a problem?

Many agencies will use the SWP Delivery Reliability report for many purposes. In addition, Calsim II is the basis for many water program analyses.

- Local water agencies will use the reliability report for local planning purposes, such as developing the Urban Water Management Plans required by Water Code Section 10610. Efficient local planning requires credible estimates of SWP reliability.

- Local agencies will also use the report to comply with the requirements of SB 221 and SB 610. These laws require water retailers to certify there is sufficient water to meet the requirements of new development projects.

- The California Water Plan Update plans to use Calsim II to describe the State's water conditions. The California Water Plan is to guide the strategic development of the State's water resources.

- Calfed is using Calsim II as part of its integrated storage investigations. The result of these investigations will be recommendations for potential new water supply projects.

- All of these investigations will be used to justify future statewide water bonds

However, if the delivery reliability of the SWP is overstated and Calsim II results are questionable, the consequences would be significant.

- Local agencies will mis-size local water projects.
- Local development could be hampered if, when complying with SB 610 and SB 221 or CEQA, there are significant disputes over current and future water supplies.
- The California Water Plan would once again be subject to widespread criticism.
- Conclusions of Calfed's Integrated Storage Investigation (ISI) will be suspect given that the same model is used in both the ISI and the SWP Reliability report.
- Future statewide bonds for increasing water supply will be in jeopardy, if opponents can credibly challenge the underlying analysis.

Solutions

As the Bay-Delta Modeling Forum's Ad hoc Modeling Protocols Committee noted in their *Protocols for Water and Environmental Modeling:*

In the highly technical and political arenas of California water, it is important that models enjoy a wide base of support from stakeholders and decision-makers, technical staff, and even the public. Modeling of water systems is not just a technical exercise. The objectives of modeling are to aid in planning, policy or operational decisions. Thus, models must be developed and used in ways that (1) provide assurance to decision-makers that the analysis is reasonable, (2) can be trusted by reasonable parties, and (3) addresses major technical concerns for the system's performance. – Protocols for Water and Environmental Modeling, January 21, 2000, p. 5

Unfortunately, Calsim II as used in the draft SWP Delivery Reliability report fails these requirements. While some of the issues raised about the report are misplaced, there are still a significant number of legitimate concerns.

Department's plan to hold peer review, historic simulation, and sensitivity analysis of Calsim II is a good start toward restoring confidence, though there are some concerns.

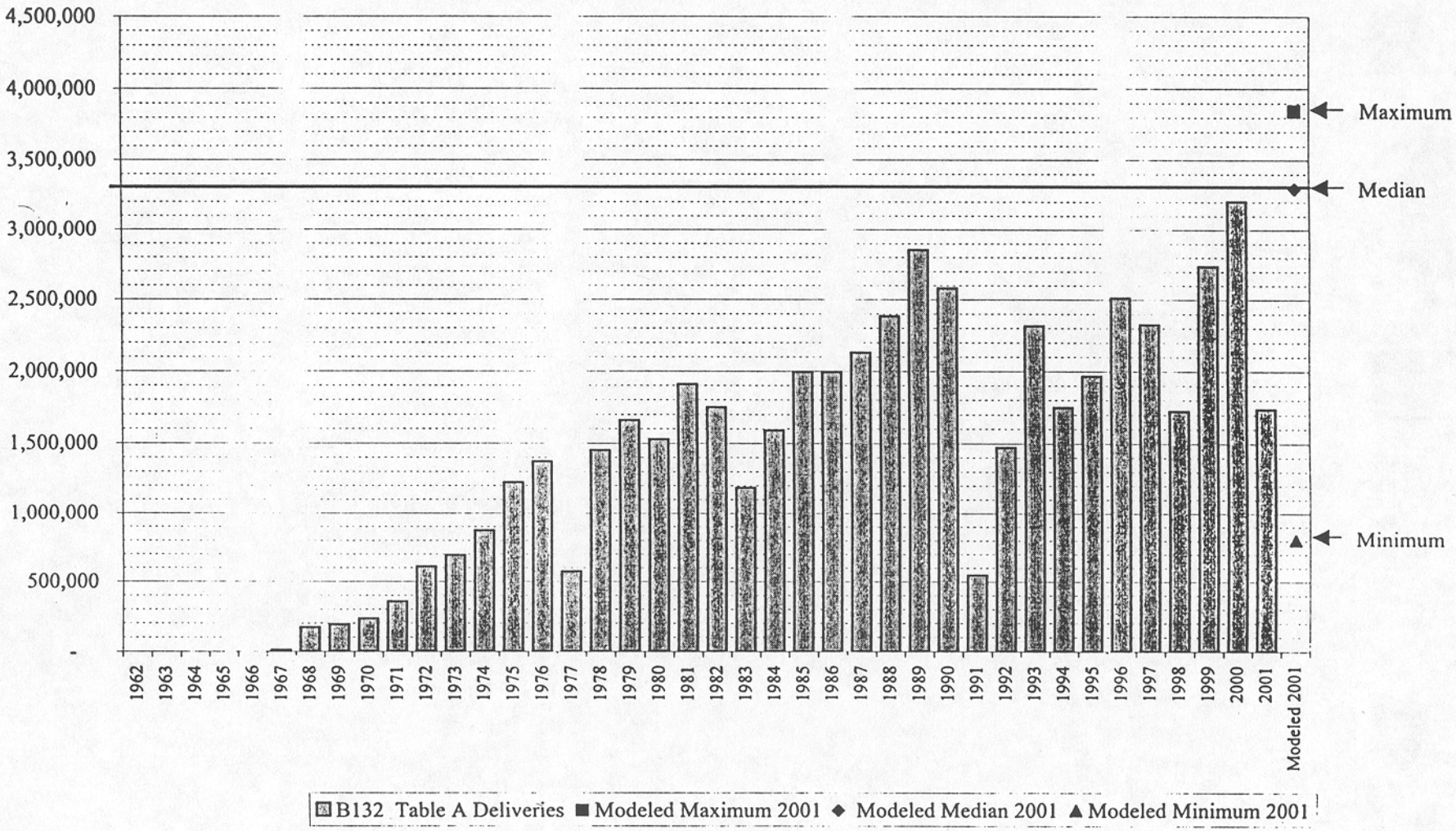
- The peer review etc. will only suggest whether there is something structurally wrong with the model or its logic. It is possible that the model is properly designed, but the underlying data and assumptions are in error, leading to questionable output. The peer review will not show this.
- There is concern about simulating the recent past. Each year's estimate will explain only itself – results for one year do not necessarily imply anything about the accuracy of any other year. In statistical terms, it is equivalent to having zero degrees of freedom.

- It is unclear what the standard or threshold for acceptance or rejection of current model approach is. This will need to be clearly stated before the testing process begins.

It is critical that this report's conclusions have widespread support. Unless and until the Department makes a concerted effort to resolve the concerns of the report's critics to the critics' satisfaction, the report seems premature. From a public policy perspective, it is better not to issue a final report, than to have a final report subject to significant dispute.

Chart 1

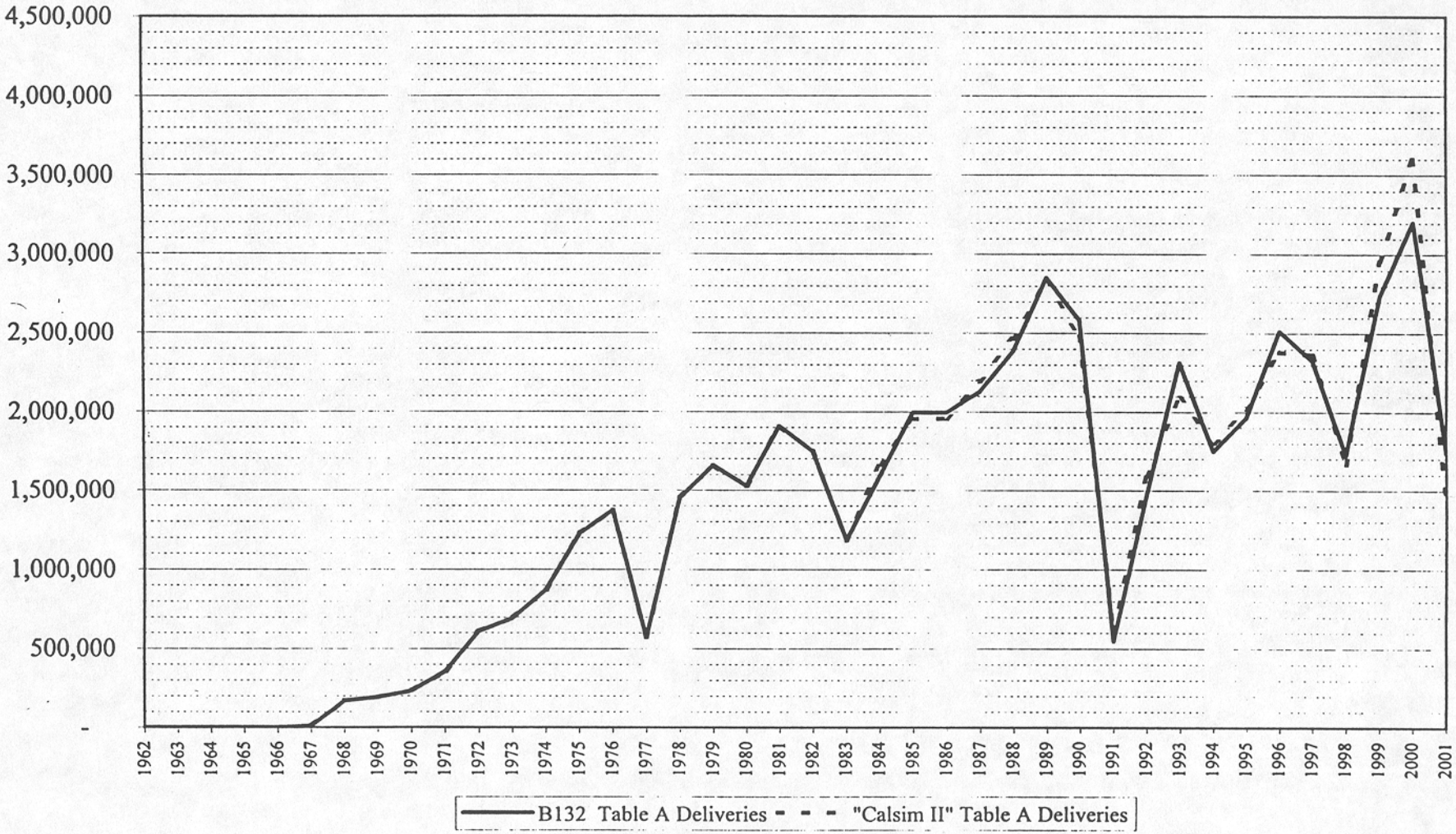
Compared To Historic Table A Deliveries,
The Modeled 2001 Delivery Reliability Looks High
(Not once do deliveries reach the median delivery rate)



Entitlement Deliveries
(Bulletin 132-00, Table 9-4 Draft Reliability Report, Appendix D)

Chart 2

The Difference Between Actual Table A Deliveries
As Reported In Bulletin 132 And As Calculated In Calsim II
(Eg., CalSim II counts carryover water in the year it is created, not the year it is delivered)



Entitlement Deliveries as reported in B-132 and as calculated in CalSim II
(CalSim II deliveries calculated per e-mail conversation with Frances Chung)

Chart 3

Still, The Actual Table A Deliveries (Adjusted) Look High
Compared To The Modeled 2001 Delivery Reliability
(Only once do deliveries reach the median rate)

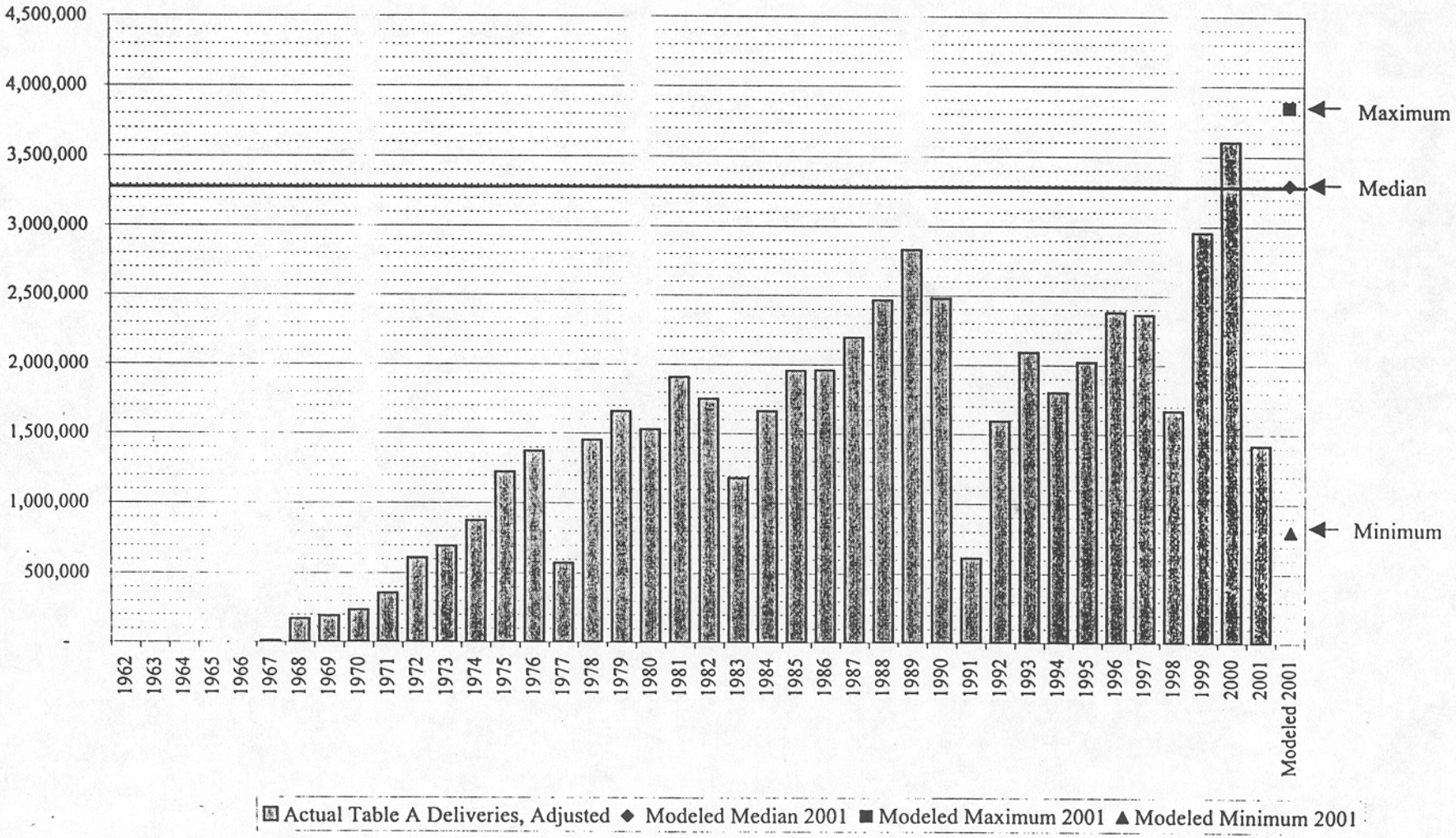


Chart 4

The Same Picture Holds When Including Article 21 (Surplus) Water
Modeled Deliveries Look High Relative To History
(Only once do deliveries reach the median rate)

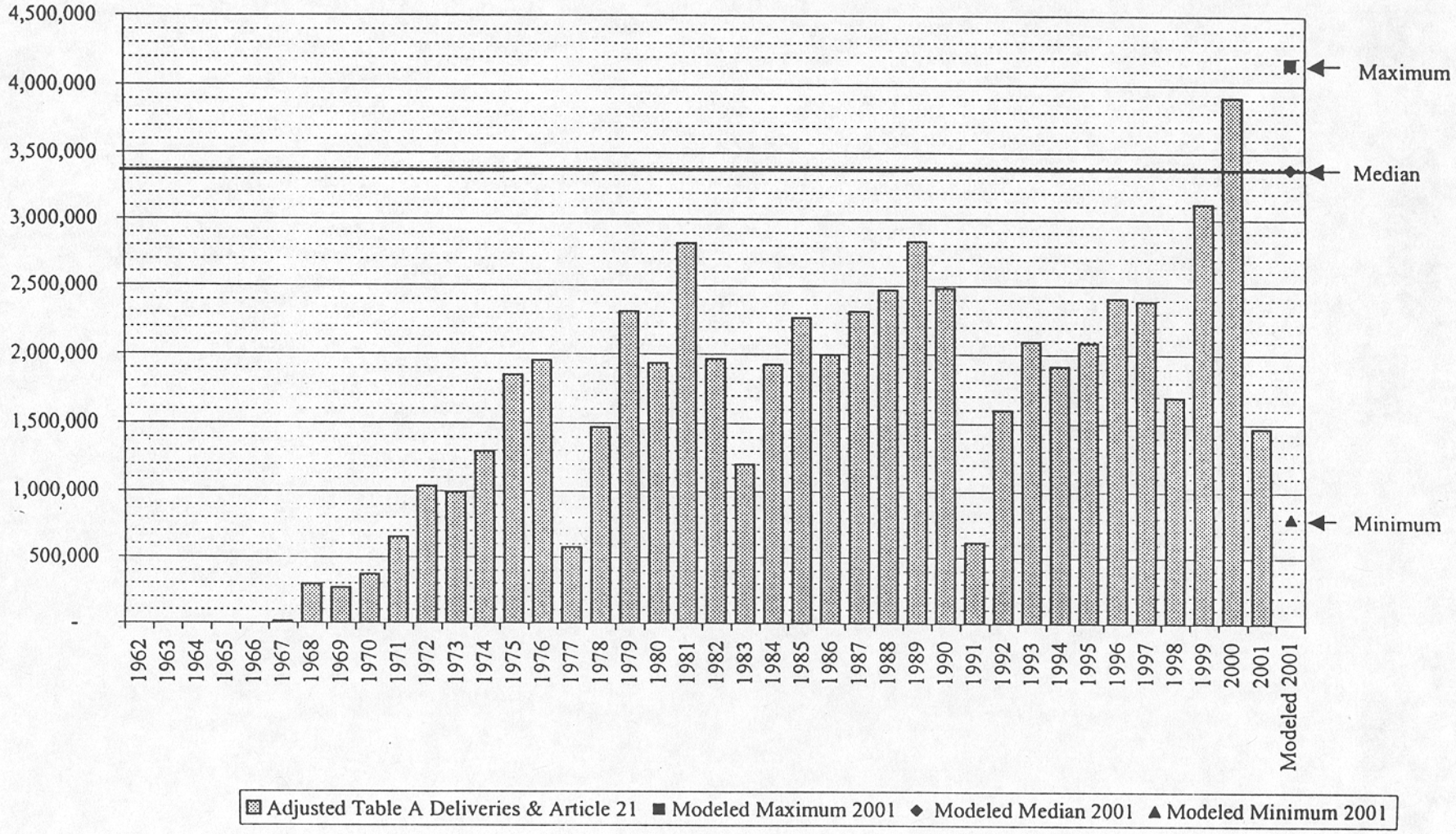
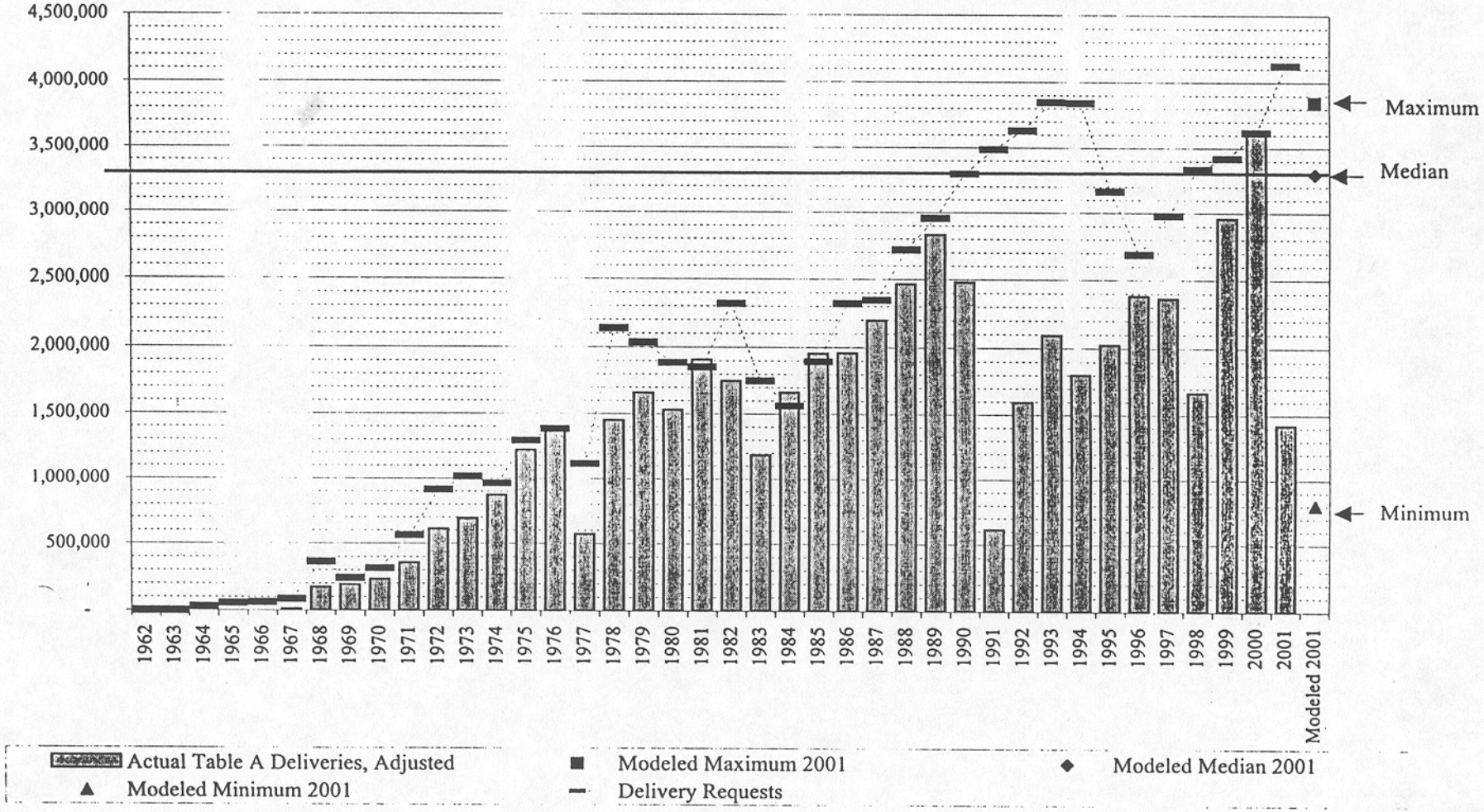


Chart 5

The Apparent Discrepancy Between Historic Deliveries And Modeled Reliability Doesn't Seem To Be An Issue Of Demand Vs. Capacity

(9 times requests have exceeded the median rate, only once has the median rate been exceeded)

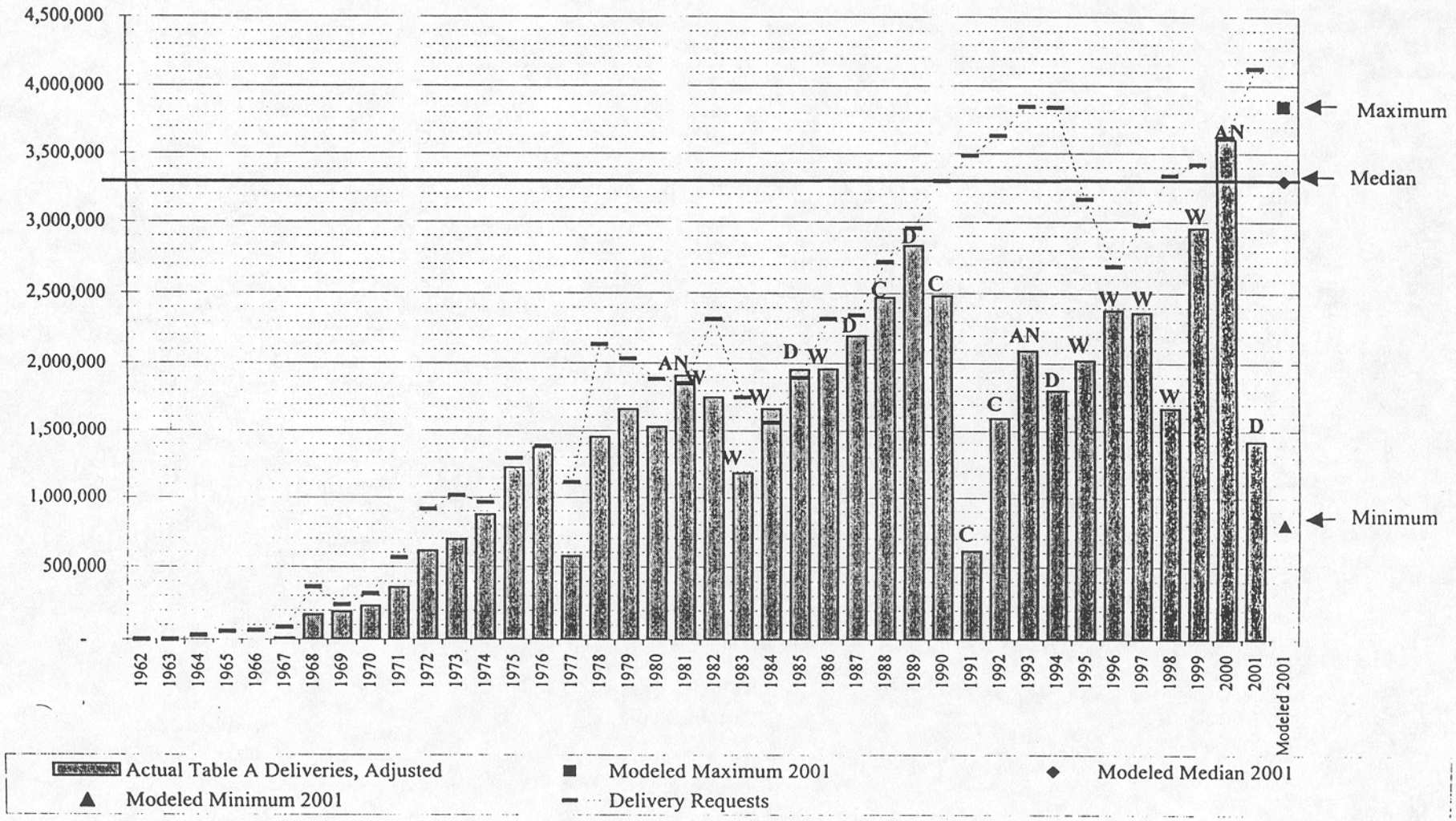


Source for Requests: Frances Chung and spot checked against B132 various years

Chart 6

Nor Does Water Year Type Seem To Explain The Discrepancy

(Eg., 1998 was a wet year, requests were greater than the median rate,
yet contractors received only half of their requested amount (as defined by Calsim II))



Water year type based on the Sacramento River Index

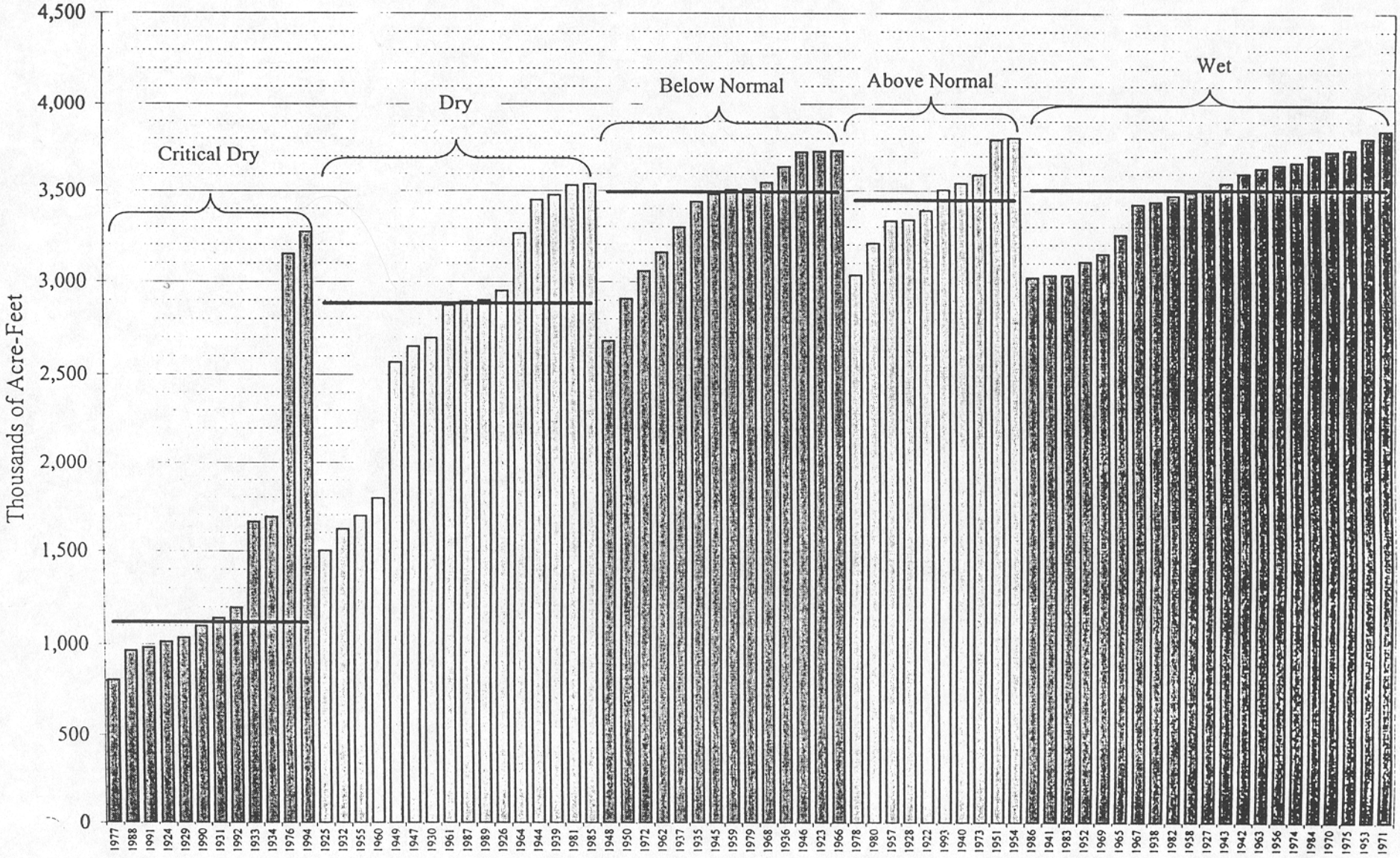
W -- Wet AN -- Above Normal BN -- Below Normal D -- Dry C -- Critically Dry

Chart 7

2001 Modeled Reliablity Curves Sorted By Water Year Type

Show The 50 Percent Exceedence Rate Is *Higher* In Below Normal Years Than In Above Normal Years

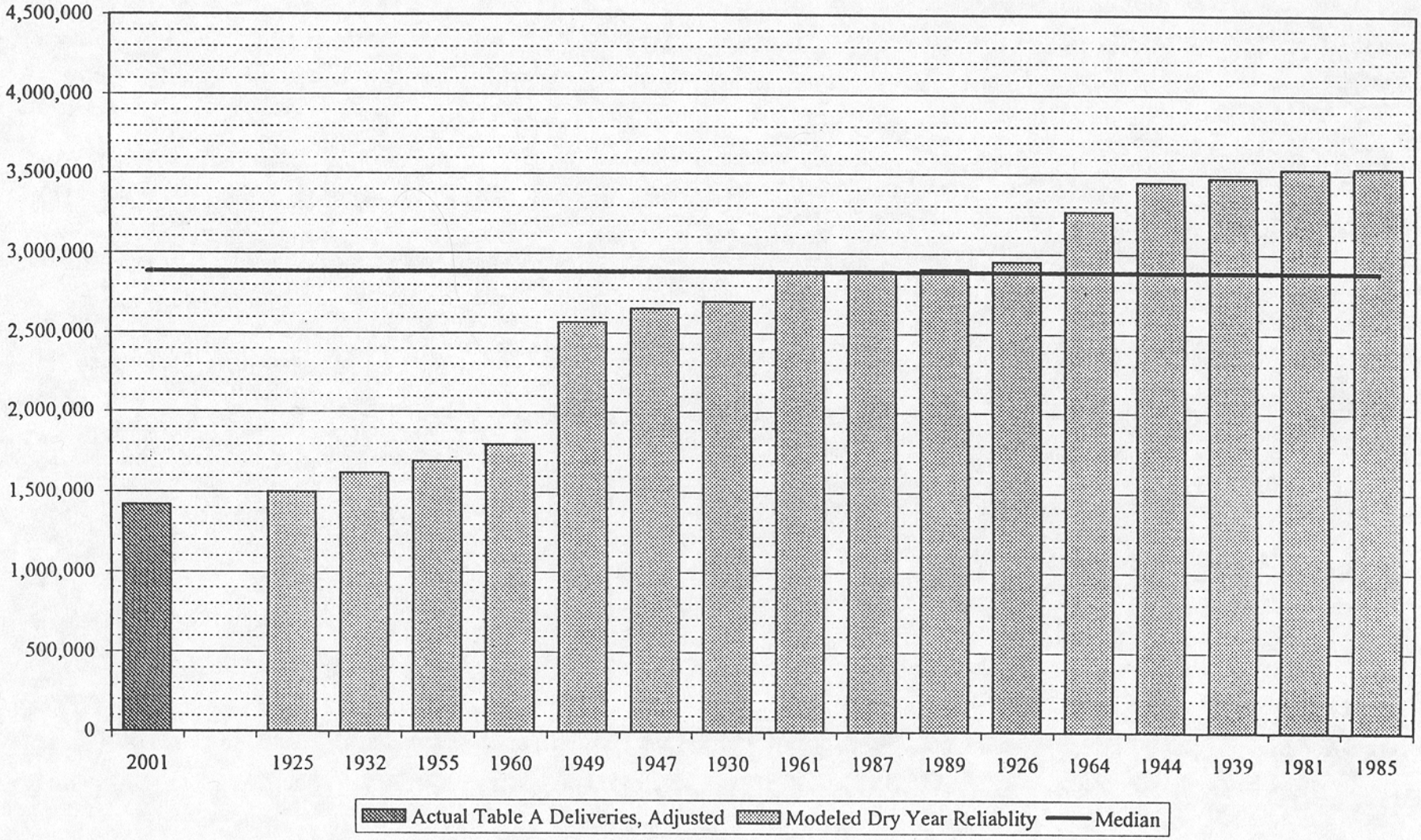
(Bold line shows the 50 percent exceedence rate for each water year type)



(Table B-3 "Model Delivery" grouped by Sacramento River Index water year type)

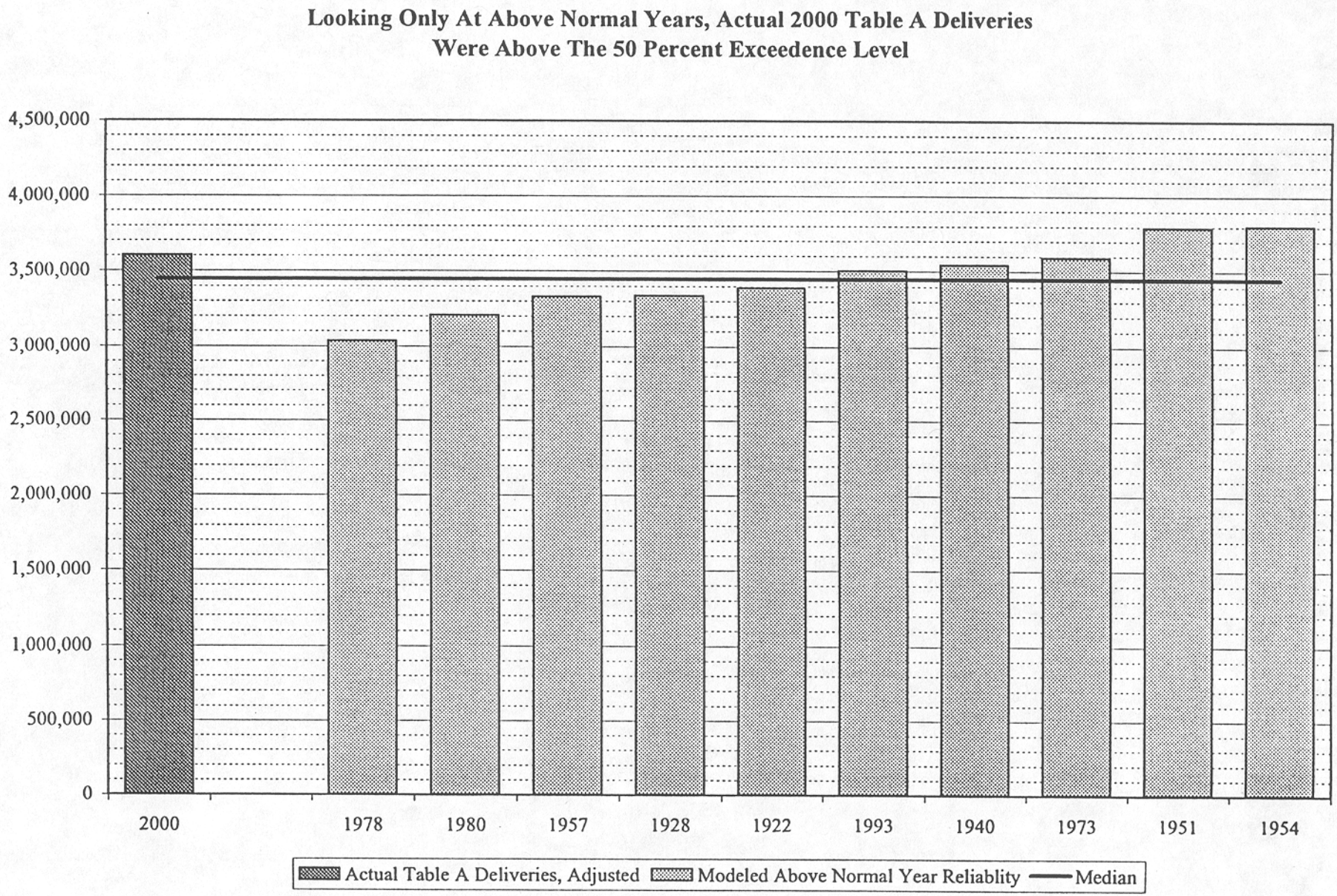
Chart 8

Looking Only At Dry Years, Actual 2001 Table A Deliveries Were Less Than The Least Amount The Model Says Would Ever Be Delivered



(Table B-3 "Model Delivery" for Sacramento River Index "dry" years)

Chart 9

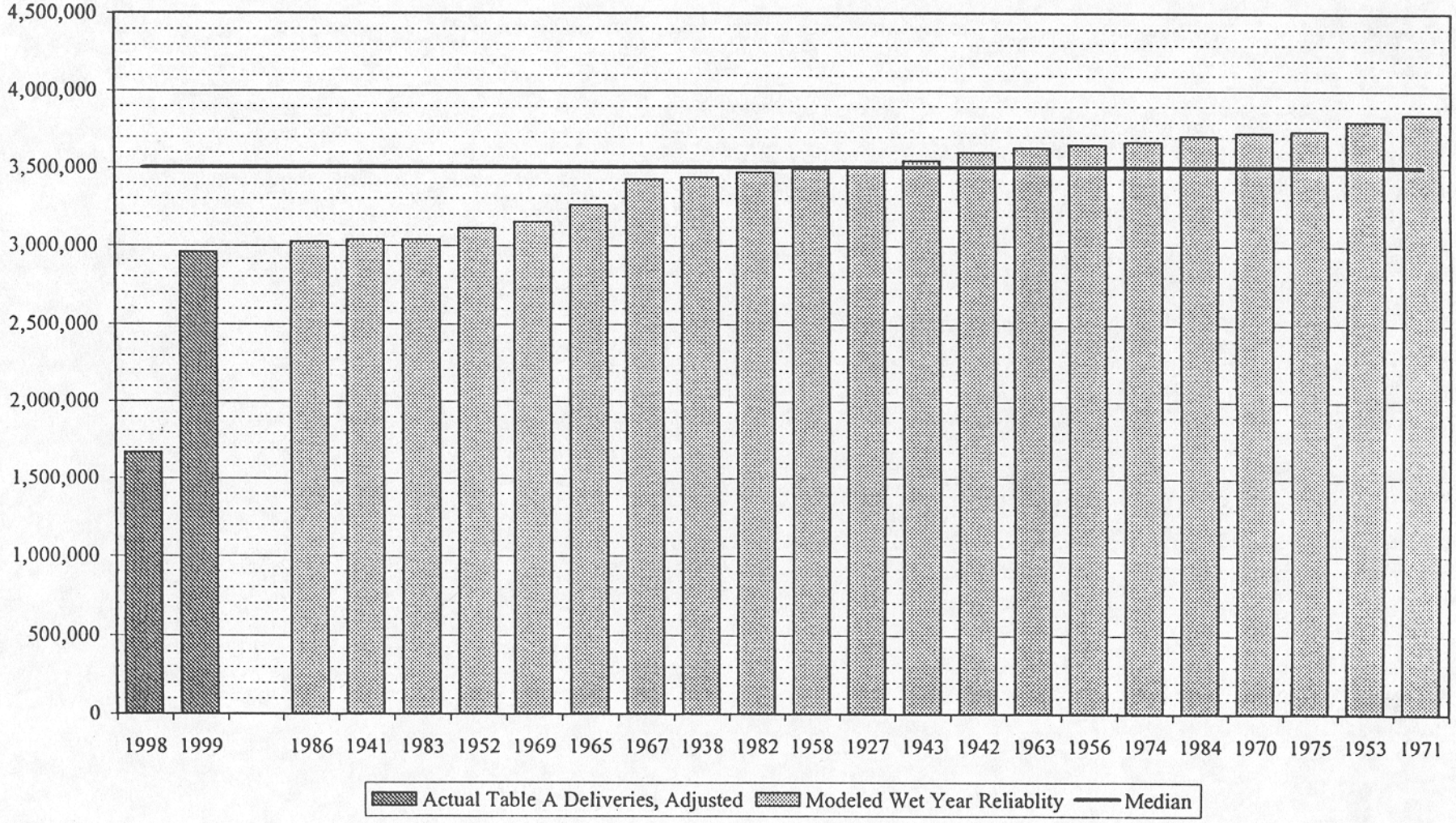


(Table B-3 "Model Delivery" for Sacramento River Index "above normal" years)

Chart 10

Looking Only At Wet Years, Actual 1998 & 1999 Table A Deliveries Were Less Than The Least Amount The Model Says Would Ever Be Delivered

(1998 was 45 percent lower than the "least" amount)



(Table B-3 "Model Delivery" for Sacramento River Index "wet" years)