No. 65, Original

In the Supreme Court of the United States

October Term 1983

STATE OF TEXAS,
Plaintiff

v.

STATE OF NEW MEXICO,
Defendant

UNITED STATES OF AMERICA,
Intervenor

REPORT AND RECOMMENDATION

Jean S. Breitenstein
Special Master

C-446 United States Courthouse
1929 Stout St.
Denver, Colorado 80294

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REPORT AND RECOMMENDATION OF SPECIAL MASTER

INTRODUCTION

The Special Master believes that submission of this Report and Recommendation is appropriate under the 1975 order of his appointment. 423 U.S. 942. The case presents a controversy over the Pecos River Compact intended by the signatory States to apportion the use of the water of the Pecos River.

With stated exceptions, the Compact imposes on New Mexico, the upstream State, an obligation not to deplete the state-line flow below that available to Texas under the "1947 condition." The Master rejected the conflicting contentions of the States and defined the phrase. The Court approved his definition, 446 U.S. 540. The definition was:

> "The 1947 condition is that situation in the Pecos River Basin which produced in New Mexico the man-made depletions resulting from the stage of development existing at the beginning of the year 1947 and from the augmented Fort Sumner and Carlsbad acreage."

The legal definition must be translated into water quantities to provide a numerical standard for measurement of compliance. By its June 17, 1983 decision, 103 S.Ct. 2558,

the Court returned the case to the Special Master for a final decision on the basic issue in dispute, the compliance of New Mexico with the obligations imposed by the Compact. In so doing it stated that "there seems to be no more than three or four issues upon which the Special Master will have to resolve difficult questions of fact or of hydrological method." 103 S.Ct. 2558 at 2571, n. 21.

At a hearing on July 21, 1983, the States agreed that only five issues remained to be resolved by the Special Master and the evidence on those issues was complete. The Special Master resolved those five issues by his Report dated September 28, 1983. He denied objections thereto by Order of November 10, 1983.

Texas submitted a river routing study in compliance with the Order. New Mexico filed objections and Texas has responded. The Special Master disposed of the New Mexico objections to the Texas river routing study by his Order of January 9, 1984. That Order requires that Figure 1 and Table 1 of Texas Exhibit 68, pp. 3 and 4, be used in the determination of New Mexico departures from the obligation imposed by the Pecos River Compact Art. III (a).

There remains to be done in the case the determination of the New Mexico departures and, if they are negative, whether those departures are the result of man's activities. From his experience in the case, the Special Master believes that two to three years will be required to complete this task.

Because of the use of acronyms in the Reports of the Special Master, it is noted that S.D. 109 refers to the Report of the Chairman of the Senate Interior and Insular Affairs Committee when the bill for congressional consent to the compact was pending. See Senate Document 109 81st Cong., 1st Session. S.O. 1947, summary of operations 1947, is a river routing study presented to the Compact negotiators by their engineers. RBD, Review of Basic Data, is a river routing study presented by the engineers to the Commission and used by it in a limited fashion.

RECOMMENDATION

In accordance with Compact Art. III (a), New Mexico shall not deplete by man's activities the flow of the Pecos River at the New Mexico – Texas state-line below an amount which will give to Texas the quantity of water represented by Figure 1 and Table 1 of Texas Exhibit 68, pp. 3 and 4.

BACKGROUND

The background of this controversy is portrayed in the Special Master's September 7, 1979 Report to the Supreme Court which was affirmed in 446 U.S. 540 and in the Special Master's September 10, 1982 Report which was reversed in part and affirmed in part by the Court's decision of June 17, 1983, 103 S.Ct. 2558.

For the information of the Court, there follows:

1 – Copy of Report and Order entered September 28, 1983.

2 – Copy of Order entered November 10, 1983.

3 – Copy of Order entered January 9, 1984.

REPORT AND ORDER

By its June 17, 1983, decision in this case, Texas v. New Mexico, the Supreme Court returned the case to the Special Master "for a final decision on the basic issue in dispute — whether New Mexico is in compliance with obligations imposed by the Pecos River Compact." Slip Opinion, p. 1. In so doing the Court sustained the objection of the United States and New Mexico to the Master's Report that the Court appoint a tie-breaker on the Commission created by the Compact. The Court also held without merit the New Mexico contention that it could only review actions taken by the Pecos River Commission and the Texas insistence that the "Double Mass Analysis" be substituted for river routing.

In 1980 the Court approved the Master's definition of the obligation of New Mexico under Compact, Art. III(a), which was that "[t]he 1947 condition is that situation in the Pecos River Basin which produced in New Mexico the man-made depletions resulting from the stage of development existing at the beginning of the year . . ." 446 U.S. 540. That definition must be translated into quantities of water to become workable. The Court recognized this. It said that the curve produced by the Summary of Operations 1947, S.O. 1947, as described by the original Inflow-Outflow Manual "does not accurately describe the correlation between inflows and the state-line outflow under the 1947 condition." Slip Opinion, p. 18. The Court also rejected the New Mexico reliance on the Review of Basic Data, RBD. The Court approved the Master's recommendation that RBD was only operative as the Commission's finding of a New Mexico negative departure for the period 1950-1961, without a statement of the cause. Slip Opinion, p. 12, n. 12. The disputes between the States go to differences between S.O. 1947 and RBD.

The Court characterized these disputes thus, Slip Opinion p. 20, n. 21:

> "At this stage of the litigation, there seems to be no more than three or four issues upon which the Special Master will have to resolve difficult questions of fact or of hydrological method."

The problem is to go back to the beginning of the year 1947 and recreate the stream flows. S.O. 1947 used the period 1905-1947 for the task. The RBD used the period 1919-1947. The Inflow-Outflow Manual prepared by the Engineering Advisory Committee to the Compact Commissioners utilized flood inflows to make up 50% of the inflow indices. Flood inflows can only be estimated. The Court noted this in Slip Opinion, p. 3, n. 5, where it commented that "many entries – e.g., the three columns showing 'flood inflows' and the two columns entitled 'channel losses' – required a great deal of speculation, and to some extent they may have been used as residual categories to 'balance the books.'" This conforms with the testimony of witness

Erickson. Tr. 966. The Court also noted, Slip Opinion, p. 5:

> "In almost every year following adoption of the Compact, state-line flows were significantly below the amount that one would have predicted on the basis of the Inflow-Outflow Manual, with no obvious change either in natural conditions along the river or in 'man's activities.'"

In its description of the Pecos, Slip Opinion, p. 2, n. 2, the Court notes that the "Pecos may dry up completely for weeks at a time over fairly long reaches in central New Mexico." This is because of the geology of the area. There are three sources of the water. It may come from surface flows, from shallow aquifers which are fed by surface flows and, in turn, may add to the surface flows, and from artesian aquifers which both draw water from, and contribute to the shallow aquifers.

The situation is further complicated by pumping of water for uses in agriculture. Up to 1937, pumping by New Mexico farmers increased drastically in the Roswell area. In that year New Mexico passed a law regulating the use of ground water which had some deterrent effect on pumping. At about that time a change occurred in the regimen of the river. It no longer produced the base flow that was produced in former years. The engineers had no explanation for this. Flook, Tr. 4341-4342. The change continued until 1941 when there was a very heavy rainfall, exceeding any in the basin since 1878.

The magnitude of this rainfall was such that S.O. 1947 shows the inflow to Red Bluff as 1,650, 400 acre feet and RBD as 1,664,000 acre feet, more than three times as large as that occurring either before or after. The results of the heavy precipitation showed in future years. Much of the rain went to recharge the sources of the subsurface supply, both shallow and artesian. Other portions went into bank storage. The area at the head of McMillan Reservoir was inundated. Portions of the flow were lost to the river through consumption by phreatophytes. It was at least three years before the stream returned to pre-1941 conditions.

Given a stream with all the peculiarities of the Pecos, it is to be expected that the hydrologists will differ and will approve different numbers to reflect the condition at the beginning of 1947. We are looking at the stream from hindsight and attempting to define the New Mexico obligation. We have available almost as many years after that date as the advisors to the Compact Commission had before then. Yet under the mandate of the Court, we must do so.

Essentially, the differences between the two States are those between S.O. 1947 and RBD. The May 14, 1982, stipulation between the States narrowed the areas of dispute. On July 21, 1983, the States appeared before the Master to give their views on further proceedings in the case. They agreed upon five general areas and further agreed that the evidence before the Master sufficed for him to reach a decision. The Master on July 25, 1983, entered an order stating his understanding of the five issues. Texas has objected on technical grounds to his statements. New Mexico has accepted the Master's statement.

No question of law is involved. The Master's choice is between the engineers who testified for each side. The Master finds that all witnesses who have testified are competent and credible. The disputes involve questions on which there can be honest differences of opinion. In making the judgment calls necessary to resolve the disputes, the Master has relied heavily on the Report which he has received from his technical assistant, Raymond A. Hogan. A copy of that Report, marked Master's Exhibit 28, is made a part of the record of the case and a copy thereof is forwarded herewith to each of the States.

[N.B. For the convenience of the Court, the technical assistant's Report is appended as Exhibit 1.]

ISSUE NO. 1
HOW SHOULD CHANNEL LOSSES BE DETERMINED BETWEEN ALAMOGORDO DAM AND ACME?

Texas correctly says that the only dispute between Texas and New Mexico concerning channel losses from Alamagordo Dam to Acme is the treatment of negative flood inflow values when they arise.

For the reason stated in the technical assistant's Report, pp. 3-6, the Master's conclusion on this issue is:

> Negative flood inflows should be retained and added algebraically when determining the annual flood inflows, except where they are demonstrably the result of lag effect. Adjustments should be made for lag effect.

ISSUE NO. 2
HOW SHOULD RIVER LOSSES BE DETERMINED BETWEEN ARTESIA AND DAMSITE NO. 3?

This involves two disputes. The first concerns the Texas elimination of certain data points because of its belief that these data points were affected by lag. The difference between the States is illustrated by the equations given on p. 7 of the Report of the technical assistant. The Texas equation is not correct because its engineers were not justified in eliminating the data points. The New Mexico equation is not correct because it did not correct for lag effects.

Both States use the method of least squares to obtain their loss equations. The Master agrees with his technical assistant that the least absolute value method is preferable but if the States agree on the least squares method, he will accept it. The Master agrees with his technical assistant on this phase of the controversy and concludes:

> To determine river losses between Artesia and Damsite No. 3, it will be necessary to derive a new relationship retaining the data points eliminated by Texas and by grouping together the data points that are suspect of being affected by lag.

The second dispute between the States relates to the maximum monthly amount that should be used. Both agree that a maximum loss should be adopted but they cannot agree on the quantity. For the reasons given in the technical assistant's Report, pp. 8-9, the Master agrees with New Mexico and resolves this issue thus:

> The maximum monthly loss should be 14,300 acre-feet.

ISSUE NO. 3

WHAT IS THE CORRECT MONTHLY DISTRIBUTION OF THE IRRIGATION DEMAND FOR THE CARLSBAD IRRIGATION DISTRICT?

The amount of water involved is insignificant. For the reasons given in the technical assistant's Report, p. 10, the Master resolves this issue thus:

> The correct monthly distribution of the annual irrigation demand for the Carlsbad Project should be 11 months with no diversions in November.

ISSUE NO. 4

WHAT IS THE CORRECT RELATIONSHIP SHOWING DEPLETION OF RIVER FLOWS BETWEEN CARLSBAD AND ANGELES?

Both States agree that a depletion curve should be used for the Carlsbad to Angeles reach of the river. The difference is shown on Texas Exhibit 57. It arises from the New Mexico elimination of the data points for the years 1928, 1942, 1944, and 1945. The reasons for the elimination are given in the technical assistant's Report, pp. 11-12. The Master's conclusion is:

> It is rational to exclude the 1928, 1942, 1944, and 1945 data points. The Master accepts the depletion relationship as shown by New Mexico Exhibit 54, p. 108, Fig. 4.

ISSUE NO. 5
HOW SHOULD ARTESIAN INFLOW BE DETERMINED ACME TO ARTESIA?

New Mexico proposes the use of the RBD method for determining the base inflow between Acme and Artesia. Texas developed a correlation among the water levels in four wells, precipitation, and artesian inflow. For the reasons given in the technical assistant's Report, pp. 13-16, the Master concludes:

> The RBD procedure using precipitation as presented by New Mexico should be used to determine artesian inflow.

IT IS ORDERED:

(1) – Each State shall file with the Master, and serve on the other State, its written response to the decisions made by the Master herein together with supporting reasons for its disagreement on or before November 1, 1983.

(2) – If there are objections filed, those objections will be heard by the Master on Thursday, November 10, 1983, at 9:30 a.m., in the United States Court of Appeals Courtroom for Div. II, United States Courthouse, 1929 Stout Street, Denver, Colorado.

(3) – If there are no objections filed, Texas shall proceed to make a river routing study in accordance with the agreements of the States and the decisions made herein. Such study shall be made and a written report filed with the Master and New Mexico on or before December 1, 1983. Any objections of New Mexico to the report shall be filed with the Master, and a copy thereof furnished Texas, on or before December 23, 1983.

Dated at Denver, Colorado, September 28, 1983.

ORDER

This matter came on for hearing before the Special Master on the Responses of the States to the Master's September 28, 1983, Order. After argument and on a review of these Responses, it is ORDERED:

1. The request of Texas to cross-examine the Special Master's technical assistant is denied.

2. Any and all objections and exceptions to the September 28, 1983, Report are denied.

3. On or before Thursday, December 1, 1983, Texas shall prepare, file with the Special Master, and serve upon New Mexico:

(a) – A revised river routing study and inflow-outflow curve based on the stipulation of the parties and on the decisions of the Special Master.

(b) – Accompanying (a), Texas shall submit and file a sufficiently detailed Engineering Report which shall contain a computer model of the Pecos River showing how the river routing study was performed and how the computer model operates.

4. On or before Friday, December 23, 1983, New Mexico shall submit and file with the Special Master, and serve upon Texas, an Engineering Report specifying the issues or disagreements which it has with the submittal of Texas.

5. If either State files any objections to the submission of the other State, these objections will be heard by the Special Master on Tuesday, January 3, 1984, at 9:30 A.M., in the United States Court of Appeals, Div. II Courtroom, United States Courthouse, 1929 Stout Street, Denver, Colorado.

Dated at Denver, Colorado, November 10, 1983.

[N.B. The reason for the denial of the right to cross examine the Special Master's technical assistant was that Rule 706 (a), F. R. Evid. giving the parties the right to cross-examine a court appointed expert does not apply to the Supreme Court. See Rule 1101(a), F. R. Evid.. In a spirit of cooperation the Special Master had previously permitted the cross-examination of the technical assistant. The result was a fiasco which the Special Master did not wish repeated. See Tr. pp. 3015-3247.]

ORDER

This matter came on for hearing on January 3, 1984, on the Texas revised river routing study and recomputation of the 1947 Inflow-Outflow relationship and the New Mexico objections thereto. The purpose of the study was to translate into water quantities the "1947 Condition" as that term is used in the Compact Art. III (a) and as interpreted by the Special Master's August 13, 1979, Report which was approved by the Supreme Court. See 446 U.S. 540. The Special Master has heard and considered the evidence offered, and the arguments made, by the two States.

At the hearing, the following exhibits were received in evidence:

Texas Exhibit 68	–	The Texas River Routing Study and Recomputation of 1947 Inflow-Outflow Relationship
Texas Exhibit 69	–	Computer Data used in preparation of the Texas River Routing Study
Texas Exhibit 70	–	Errata Sheet
Texas Exhibit 71	–	Texas response to New Mexico objections to its River Routing Study
Texas Exhibit 72	–	Letter from Slingerland, an engineer for New Mexico
New Mexico Exhibit 62	–	New Mexico response and objections to Texas River Routing Study
Master's Exhibit 29	–	Graph prepared by the Special Master's Technical Assistant comparing S.D. 109 curve, RBD curve, and curve prepared by Texas
Master's Exhibit 30	–	Graph prepared by the Technical Assistant showing comparison of Texas proposed curve representing its view of the New Mexico obligation with the New Mexico curve showing its view of that curve.

After hearing the evidence and the arguments of counsel, the Special Master finds and concludes:

1 – New Mexico objects to the phrase "index outflow" as used at pages 1, 2, and 19 of Texas Exhibit 68 as being an incorrect characterization. This is a difference of semantics. The Texas exhibit treats the figures as routed outflow by a three-year average as the Compact requires. The New Mexico objection is overruled.

2 – New Mexico objects to the figure found on p. 14 of Texas Exhibit 68 as showing the capacity of Alamogordo Reservoir at elevation 4274 feet as 123.7 thousand acre feet and says that the correct figure should be 124.7. The difference amounts to an inconsequential amount of water. Texas says that it used the figure agreed to by the New Mexico engineers. The Special Master agrees with Texas that the figure 123.7 should be used.

3 – New Mexico objects to the Texas statement on p. 18 of Texas Exhibit 68 as not stating correctly the index inflow used in entering the depletion curve for the Carlsbad – state-line reach of the river. However, New Mexico agrees that Texas properly computed the index notwithstanding the description. Because the computation is correct, the New Mexico objection is noted but overruled.

4 – New Mexico complains that Texas incorrectly used the figure of 29 in computing the average annual values at p. C-77. Texas acknowledged the error and enclosed corrected copies of pp. C-25 and C-77.

5 – Texas acknowledges typographical errors in Table 2, p. 12, and encloses with its response to the New Mexico objections, p. 12 as corrected.

6 – New Mexico objects to the best fit curve of Texas as shown on its Exhibit 68, Figure 1, on the ground that it is not the best fit curve. Each State called a witness who testified in support of his State's contention. Charnes for Texas said that the New Mexico curve was objectionable hydrologically because it produced negative quantities and the use of R^2 as the coefficient of determination was not proper. The Special Master determines that the use of R^2 is but one of several criteria that may be used to test the

validity of a curve. New Mexico says that the best fit curve is that drawn by the use of its Equation 15 which is $y = -20.38999 + 0.463534x + 0.000503472x^2$. The trouble with the New Mexico equation is that it begins with a negative number and if x equals zero, the resulting determination would be a negative number. This is not an important consideration on the Pecos because the outflow is greater than zero on both the Texas and New Mexico tables showing the Inflow-Outflow relationship Alamogordo Dam to the state-line.

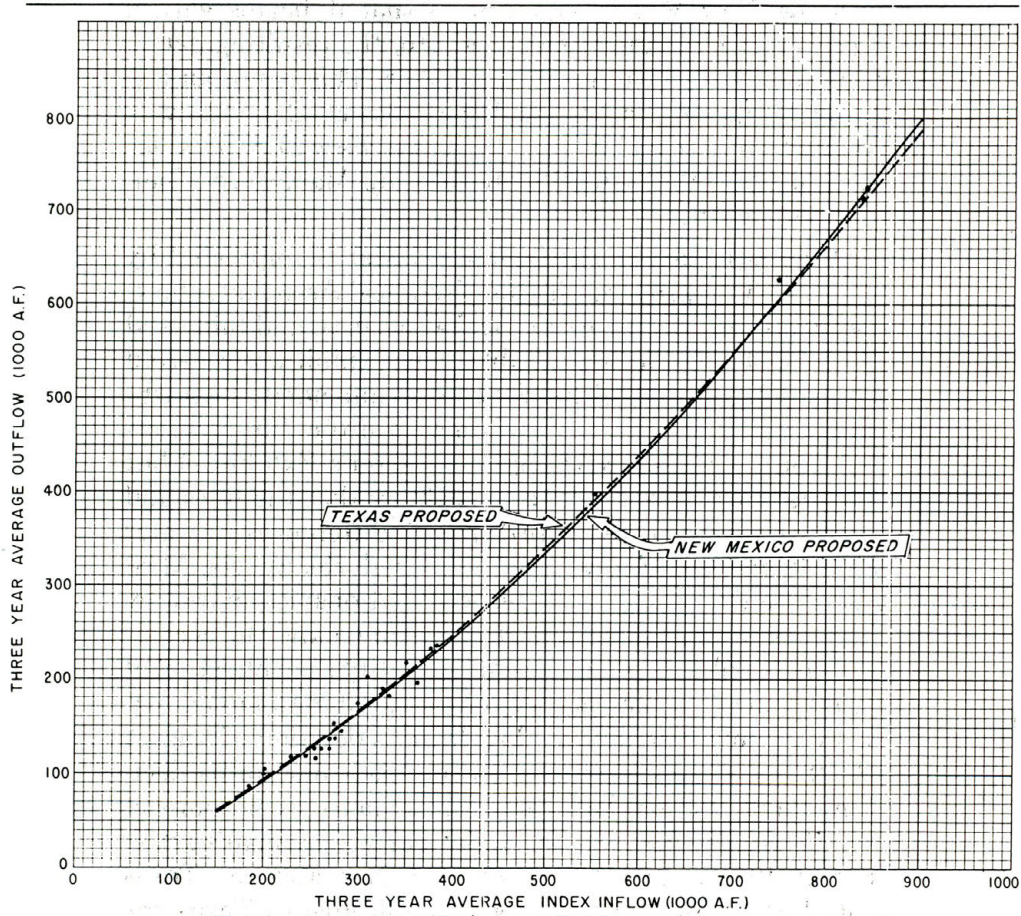
More importantly, the Special Master is impressed by his Exhibit 30 prepared by his Technical Assistant, showing the differences between the Texas curve and table and the New Mexico curve and table. This exhibit was received without objection by either State. It is appended as Attachment 1. (Note. Due to reproduction difficulties, the attachment is not an exact copy of Master's Exhibit 30 but the lines thereon are correct.). It shows that the lines and figures are practically identical. The differences in water are insignificant. Everything considered, the Special Master concludes that the curve of relationship shown by Texas Figure 1 on p. 3 of Texas Exhibit 68 and the accompanying Table 1 on p. 4 correctly quantify the obligation of New Mexico to Texas as the same is stated in Compact Art. III (a), as implemented by the Master's decision of August 13, 1979, and approved by the Supreme Court in its decision reported at 446 U.S. 540. In accordance with Compact Art. III (a), New Mexico shall not deplete by man's activities the flow of the Pecos River at the New Mexico – Texas state-line below an amount which will give to Texas the quantity of water represented by Texas Figure 1 and Table 1 in Exhibit 68. A copy of Figure 1 is appended as Attachment 2 and a copy of Table 1 is appended as Attachment 3.

Accordingly, it is ordered that the Texas Figure 1 and Table 1, see Texas Exhibit 68, pp. 3, 4 and the attachments hereto, shall be used in the determination of New Mexico departures from the obligation imposed by Compact Art. III (a).

Denver, Colorado, January 9, 1984.

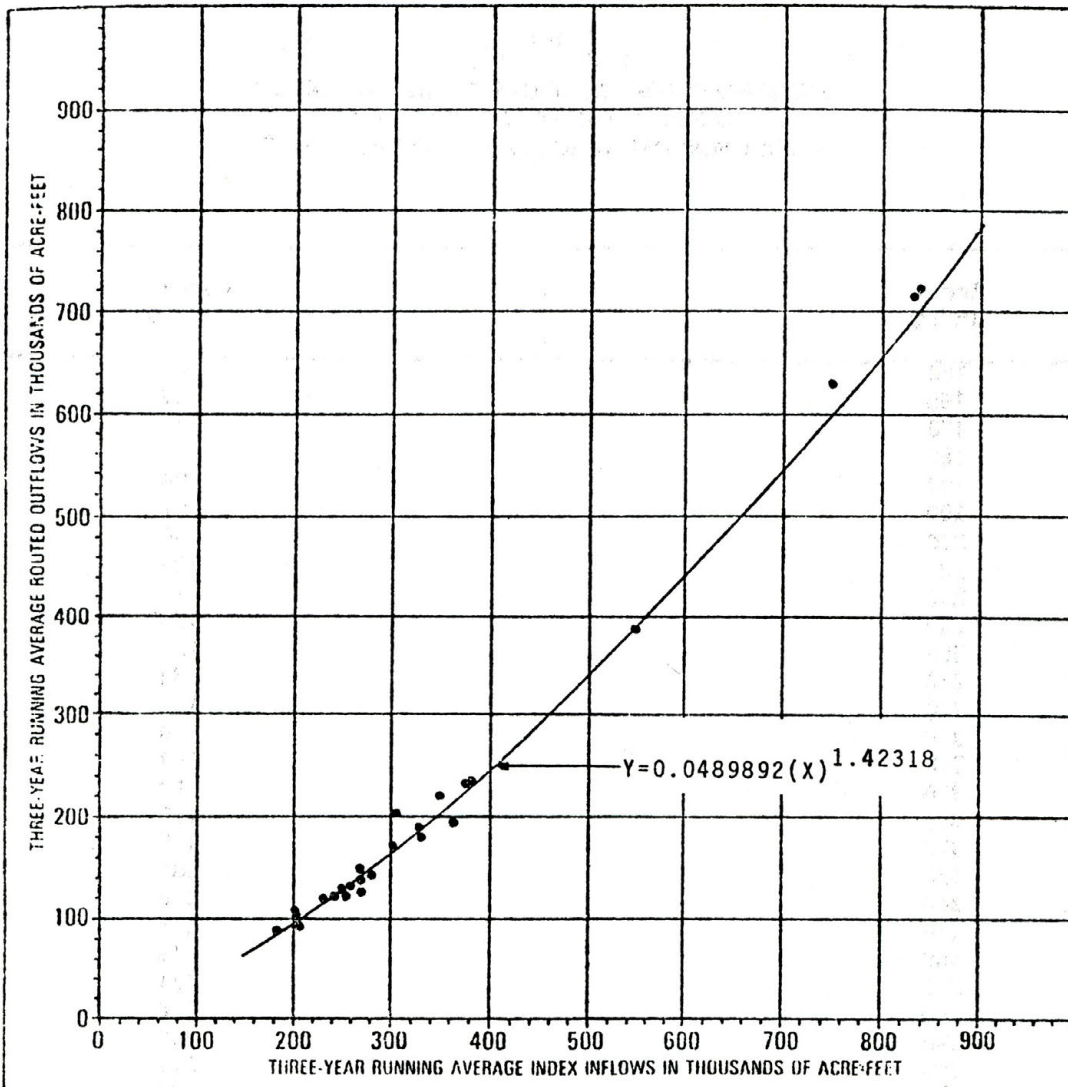
Attachment 1

REDUCED FOR REPRODUCTION



INFLOW - OUTFLOW CURVE, ALAMOGORDO DAM TO STATE LINE

Attachment 2



PROPOSED INFLOW-OUTFLOW CURVE

ALAMOGORDO DAM
TO
NEW MEXICO-TEXAS STATE LINE

FIGURE 1

Attachment 3

TABLE 1
1947 CONDITION
INFLOW-OUTFLOW RELATIONSHIP ALAMOGORDO DAM
TO NEW MEXICO-TEXAS STATE LINE
3 YEAR RUNNING AVERAGES IN 1000 ACRE-FEET

Index Inflow	Curve Outflow
150	61
160	67
170	73
180	79
190	86
200	92
210	99
220	106
230	113
240	120
250	127
260	134
270	141
280	149
290	157
300	164
310	172
320	180
330	188
340	196
350	205
360	213
370	221
380	230
390	239
400	247
450	292
500	340
550	389
600	440
650	494
700	549
750	605
800	663
850	723
900	784

CONCLUSION

On January 9, 1984, the Special Master wrote the Chief Justice asking to be relieved from his duties in this case. That request is now deferred until the Court has acted upon this Report and Recommendation.

Done at Denver, Colorado, January 16, 1984.

Jean S. Breitenstein
Special Master

SUPPLEMENTAL REPORT

On January 20, 1984, the Special Master received from New Mexico a Motion to Clarify and Amend the Order of January 9, 1984. The Motion seeks to amend the Order by adding the underlined language:

> In accordance with Compact Art. III(a), New Mexico shall not deplete by man's activities the flow of the Pecos River at the New Mexico-Texas state-line below an amount which will give to Texas the quantity of water represented by Texas Figure 1 and Table 1 in Exhibit 68 [.], provided that in determining the index inflow in the use of Texas Exhibit 68 an appropriate adjustment shall be made for any departures from the 1947 condition depletions in the reach of the Pecos River above Alamogordo Dam.

The purpose of the January 9 Order was to fix numerical standards for the legal definition of the 1947 condition as that phrase was used in Compact Art. III(a). It pertains to the stream flows at the beginning of the year 1947. The New Mexico proposed addition refers to the section of the river above Alamogordo Dam. With reference to this portion of the river the engineering advisors told the Compact negotiators that, S.D. 109, 152,

> "Any change in development in this portion of the basin can be expected to be somewhat slow so by the time it is made, a satisfactory correlation curve showing the relation between the index inflow station and the outflow station should be developed."

We are determining the 1947 condition. Development above Alamogordo Dam, if any, is for consideration in determination of the departures from the Art. III (a) obligation. It is not pertinent to the determination of the 1947 obligation. The Motion to Clarify and Amend is denied.

Denver, Colorado, January 24, 1984.

Jean S. Breitenstein
Special Master

THE REPORT OF THE TECHNICAL ASSISTANT DATED SEPTEMBER 21, 1983

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INTRODUCTION

In accordance with the Master's order dated December 29, 1981, Texas and New Mexico submitted statements with regard to basic facts, unmeasured values, and techniques to be used in the determination of stream flows. The Texas statement is contained in Texas Exhibit 48 and the New Mexico statement is contained in New Mexico Exhibit 54.

A hearing was held from March 8, 1982 through March 16, 1982, at which Texas and New Mexico presented testimony and evidence concerning unresolved issues. On May 14, 1982, the Master received a stipulation of agreement on specified matters related to the March 8-16, 1982 hearing. On September 10, 1982, the Master submitted a "Report and Recommendations" to the Supreme Court of the United States. The report included legal issues rather than the technical issues addressed during the March 8-16, 1982 hearing. After the Supreme Court of the United States rendered its decision on the legal issues, the case was continued and a hearing was held on July 21, 1983. At this hearing Texas and New Mexico requested that the Master decide the unresolved technical issues presented at the March 8-16, 1982 hearing. On July 25, 1983, the Master entered an order setting forth the five unresolved issues.

The five unresolved issues are as follows:

1. How should channel losses be determined between Alamogordo Dam and Acme?
2. How should river losses be determined between Artesia and Dam Site No. 3?
3. What is the correct monthly distribution of the annual irrigation demand for the Carlsbad Project?
4. What is the correct relationship showing depletion of river flows between Carlsbad and Angeles?
5. How should artesian inflow be determined between Acme and Artesia? *–1–*

The purpose of this report is for the Technical Assistant to present the position of each state on the unresolved issues to the Master along with recommendations and conclusions of the Technical Assistant. The reasoning used by the Technical Assistant in making these recommendations and conclusions is explained in detail to assist the Master in resolving the five issues. *–2–*

HOW SHOULD CHANNEL LOSSES BE DETERMINED BETWEEN ALAMOGORDO DAM AND ACME?

Texas utilized a "best fit" curve technique for determining the channel loss between Alamogordo Dam and Acme. The channel loss equations determined by Texas are presented in Texas Exhibit 48, page 9 and New Mexico Exhibit 54, page 35. These equations are reproduced in the following table:

Channel Loss Equations
Alamogordo Dam to Acme Gage

Month	Loss Equations
January	L = 0.1 X + 0.3
February	
December	
March	L = 0.04 X + 0.79
April	L = 0.115 X + 0.77
May	
June	L = 0.07 X + 3.91
July	L = 0.15 X + 1.80
August	L = 0.13 X + 0.79
September	L = 0.09 X + 1.11
October	
November	L = 0.025 X + 0.59

where X = flow past Fort Sumner Project in 1,000 ac-ft.
L = loss in 1,000 ac-ft.

New Mexico agreed to these channel loss equations *provided* that a water balance is maintained in determining flood inflows and with the understanding that all computed negative flood inflows be retained, except where they are demonstrably the result of lag effect for which an appropriate adjustment can be made (Texas Exhibit 54, P.32-34). Texas contends that negative flood inflows

caused by lag should be retained and all others should be set to zero (Texas Exhibit 62, P.4). –3–

Lag effects are simply caused by the time of travel of the water from an upstream to a downstream measuring point. For example, if the travel time between an upstream gage and a downstream gage is one day and if a flood with a magnitude of 10,000 acre-feet is measured at the upstream gage on September 30, the downstream gage will not reflect this flood until the following month, October 1. Therefore, when performing a water balance on a monthly basis, the error of 10,000 acre-feet caused by the time lag effect will result.

In order to understand the issues of maintaining a water balance and negative flood inflows, consider the following examples. A water balance equation between an upstream and a downstream gage on a river would be as follows:

Downstream Flow = Upstream Flow + Flood Inflow − Channel Loss

or

Flood Inflow = Downstream Flow − Upstream Flow + Channel Loss

For Example 1, assume that the measured upstream flow during a particular month is 50,000 acre-feet, the measured downstream flow is 47,000 acre-feet, and the channel loss is estimated to be ten percent of the upstream flow. The calculated flood inflow using the water balance (water budget) technique would be 2,000 acre-feet (47,000 − 50,000 + 5,000 = 2,000).

For Example 2, assume that the measured upstream flow during a particular month is 50,000 acre-feet, the measured downstream flow is 44,000 acre-feet, and the channel loss is estimated to be ten percent of the upstream flow. The calculated flood inflow using the water balance technique would be −1,000 acre-feet (44,000 − 50,000 + 5,000 = −1,000).

Neither Texas or New Mexico would disagree with the calculation of flood inflow using the agreed upon channel loss equations for Example 1. For Example 2, Texas would

set the flood inflow for that month to zero and New Mexico would retain the negative 1,000 acre-feet for that month in its calculations *-4-* of flood inflow for the year. When Texas sets the flood inflow to zero, a water balance is no longer
maintained. In the water balance equation for Example 2, according to Texas, the downstream flow would be equal to 45,000 acre-feet (50,000 + 0 − 5,000 = 45,000) when the actual flow is only 44,000 acre-feet. Mr. Martin, a witness for Texas, admitted that setting negative flood inflows to zero will not maintain a water balance (Transcript P.4128).

Mr. Slingerland, a witness for New Mexico, correctly explained why it is necessary to maintain a water balance and why negative flood inflow residuals should be retained. His testimony is reproduced in part as follows:

> "When you use average conditions for loss relations and other gain and loss items in a water balance procedure you will result in computing negative values. The actual data scatters both plus and minus from the average condition. Therefore, when you use an average condition the results will also scatter both plus and minus and it is not appropriate to alter the negative inflow values to zero, even though it is obvious that such values are in error because of data dispersion. To compensate for errors in one direction, the flood inflow values determined, regardless of sign, must be used in the routing study. If you discard the negative value in a water budget procedure, it has the effect of inflating flood inflows" (Transcript P.4195).

Since Texas and New Mexico have agreed to the channel loss equations and the Technical Assistant concurs with New Mexico on this issue, it is not necessary to address the sub-issues 3 and 4 contained in the Master's order. These issues are related to the question of which data points should be used and which method should be used to obtain the best fit curve.

The Technical Assistant finds that the channel loss equations agreed to by Texas and New Mexico and reproduced herein should be utilized in determining the channel losses between Alamogordo Dam and Acme. The Technical Assistant further finds that it is necessary to maintain a water balance and that all computed negative flood inflows should be retained and added algebraically when determining the annual flood inflows, except where they are demonstrably the result of lag effect. An appropriate adjustment for lag –5– effect should be made by averaging months together or by using other procedures mutually agreeable to Texas and New Mexico. If negative flood inflow residuals are not retained, this would have the effect of inflating the annual flood inflows. –6–

HOW SHOULD RIVER LOSSES BE DETERMINED BETWEEN ARTESIA AND DAMSITE NO. 3?

The first dispute between Texas and New Mexico can best be described by referring to New Mexico Exhibit 56. New Mexico utilized all of the data points from 1938 to 1947 to establish their loss equation. Texas utilized the same basic data that was obtained from the "Review of Basic Data," but when establishing their loss equation they eliminated certain high and low loss data points (Texas Exhibit 54, P.4). Their reason for eliminating these data points was that they believed these data points were affected by lag. Texas did not correct the data points for lag because of the lack of daily streamflow data for the complete record (Texas Exhibit 54, P.4). The data points eliminated by Texas are shown in red on New Mexico Exhibit 56. The loss equations developed by the states are as follows:

$$\text{Texas } Y = 0.33\,X + 0.28$$
$$\text{New Mexico } Y = 0.39\,X - 0.42$$

where Y is the loss in thousands of acre-feet between Artesia and Damsite No. 3 and X is the monthly streamflow at Artesia in thousands of acre-feet.

The Texas equation is not correct because they were not justified in eliminating the data points and the New Mexico equation is not correct because they did not correct the data points for lag effects. The New Mexico witness, Mr. Slingerland, admitted this deficiency on New Mexico's part when he testified, when it is certain that the data points are a result of lag effects, it would be a much better procedure to group those months rather than delete the data points (Transcript P.4200, P.4224). The procedure for correcting the data points for lag suggested by Mr. Slingerland is reasonable and should be adopted.

After the data points are corrected for lag effects, it will be necessary to construct a new "best fit" line to obtain a new equation for the loss which will probably lie somewhere between the Texas and New Mexico equations. –7–

Texas and New Mexico both used the method of least squares to obtain their loss equations. The Texas witness, Mr. Charnes, testified that the least absolute value method would give the best value for the criterion. The Technical Assistant concurs that the least absolute value method is superior to the least squares method. This is a matter of preference and if both states agree to use the least squares method, the Master should not reject the method. If, however, the states cannot agree on the method to be used, the Technical Assistant recommends using the superior least absolute value method.

The second dispute between Texas and New Mexico relates to the maximum monthly loss that should be used. Both states agree that a maximum loss should be adopted, but they cannot agree on the quantity. Texas maintains that the maximum monthly loss should be equivalent to the net evaporation on a 15,000 acre lake surface area at Lake McMillan (Texas Exhibit 48, P.10). New Mexico proposes a maximum monthly loss of 14,300 acre-feet.

The New Mexico witness, Mr. Slingerland, testified that Texas used the wrong acreage and did not consider the possibility of water going into groundwater and soil storage (Transcript P.4203). Mr. Slingerland also correctly testified as follows:

> "There were some engineering calculations made of what the maximum loss from the system you might expect. One of the troubles with trying to establish a precise monthly relation based on acreage and evaporation rate is the fact that when you have a large flood, the McMillan delta is inundated, the water leaves the channel and floods the entire area. Tremendous amounts of water go into storage, both groundwater and soil storage, and is available for use in subsequent months, and the fourteen-three was the Engineering Committee's best estimate of the maximum amount of water that might be lost from the system during an event. It wouldn't necessarily be in that month, but it is lost from the system and would not reappear in the river" (Transcript P.4229).

The Texas maximum monthly loss based on acreage and evaporation on Lake McMillan must be rejected because it is contrary to physical reality. In reality, the maximum loss -8- is not only dependent upon the amount of consumptive use by the salt cedars during a particular month, but it is also dependent upon the amount of water that increases soil moisture and increases the amount of water stored in the void space in the soil when the water level rises. This increase in soil moisture and groundwater storage provides water that is available for consumptive use by the salt cedars during subsequent months. The New Mexico analysis properly took into account the increases in soil moisture and groundwater storage.

The Technical Assistant finds that neither Texas nor New Mexico presented the correct loss equation between Artesia and Damsite No. 3. Texas was not justified in eliminating the data points as shown on New Mexico Exhibit 56. The data points eliminated by Texas should be retained and the data points that are suspect of being affected by lag should be grouped together to obtain a new equation for the loss relationship. The least absolute value method for determining the best fit relationship is preferable to the

method of least squares. However, it is acceptable to use the method of least squares if both states agree. The Technical Assistant also finds that the Texas method for determining the maximum monthly loss is contrary to physical reality and is therefore rejected. The New Mexico proposed maximum loss of 14,300 acre-feet is realistic and recommended for adoption by the Master. –9–

WHAT IS THE CORRECT MONTHLY DISTRIBUTION OF THE ANNUAL IRRIGATION DEMAND FOR THE CARLSBAD PROJECT?

Texas and New Mexico agree concerning the annual irrigation demand for the Carlsbad Project, but they disagree concerning the monthly distribution of the annual demand (New Mexico Exhibit 54, P.81). Texas maintains that releases should be routed in only 10 months, February through November, as was done in Senate Document 109, rather than 11 months (all months except November), as was done in the "Review of Basic Data." New Mexico supports the "Review of Basic Data" monthly distribution, but readily admits the difference between 10 and 11 months is insignificant (New Mexico Exhibit 54, P.82).

Historically, for the period 1919-1946, diversions occurred during every month of the year. On the average, the diversions in November were about half of the diversions in either December or January (Texas Exhibit No. 64, Table I) (Transcript P.4204).

In the "Review of Basic Data" (P.13-2), it is stated that in routing the flows, the canal should be open for at least 30 days for maintenance and that November was selected as the month with no diversions because historically this was the month of least diversions. Utilizing the 11 month distribution with no diversions in November will better duplicate the historical (1919-1946) pattern of releases than the 10 month distribution with no diversions in December and January.

The Technical Assistant finds that the correct monthly distribution of the annual irrigation demand for the

Carlsbad Project should be 11 months with no diversions in November since this distribution best represents historical conditions. *–10–*

WHAT IS THE CORRECT RELATIONSHIP SHOWING DEPLETION OF RIVER FLOWS BETWEEN CARLSBAD AND ANGELES?

Texas and New Mexico agree in concept that a depletion curve should be used for the Carlsbad to Angeles reach of the river (New Mexico Exhibit 54, P.108; Texas Exhibit 57). Both Texas and New Mexico have utilized the "Review of Basic Data" information shown on Table A-20-5 and Figure A-20-1 (See also New Mexico Exhibit 54, P.108, Figure 4). New Mexico concurs with the "Review of Basic Data" curve for which the data points for 1928, 1942, 1944 and 1945 were not used in positioning the curve (New Mexico Exhibit 54, P.107). Texas contends that all data points including the years 1928, 1942, 1944 and 1945 should be used for positioning the curve because the "Review of Basic Data" fails to provide any rational basis for omitting the data for the four years (Texas Exhibit 56, P.2).

Texas is correct in that the "Review of Basic Data" (Appendix 20) does not explain its reasoning behind the exclusion of the subject data points. However, New Mexico has provided a rational basis for excluding the subject data points (New Mexico Exhibit 54, P.106-107; Transcript 4252-4253). The years 1942, 1944 and 1945 were excluded because these years followed the unprecedented rains of 1941 and contain unusual inflows, probably from the storage effect in the groundwater aquifers. The unprecedented contribution from the groundwater aquifers was verified by an analysis of the base flows or low flows for the Delaware and Black rivers. The New Mexico witness, Mr. Slingerland, testified that, "following the 1941 precipitation, the base, that part of the flow of the stream that is attributable to groundwater accretion, doubled, or in the matter of the Delaware was almost four or five times as much as you would expect under a normal circumstance." (Transcript, P.4253)

The rainfall events of 1941-1942 were certainly unprecedented in that records maintained during this century do not indicate any other similar event. By including these data points, Texas would underestimate the depletion in *-11-* most normal years to the detriment of New Mexico. If the "Review of Basic Data" depletion curve is used, the relationship will best represent "normal" conditions without the unprecedented rainfall conditions. For unprecedented rainfall years and the following years with increased gains to the river from groundwater, the "Review of Basic Data" relationship will over-estimate the depletion. However, it is doubtful that this over-estimate would be to the detriment of Texas because the extremely high streamflows would probably allow Red Bluff Reservoir to fill and spill anyway. Therefore, the equity argument would favor New Mexico's position. The rationale for excluding the years 1942, 1944 and 1945 is that the resulting relationship would better represent "normal" conditions and that the years affected by the unprecedented rains are not representative of "normal conditions."

The year 1928 was excluded as being a "sport." New Mexico explains a "sport" in this case was caused by an error in one or more of the items used to determine the data point, thereby resulting in a data point that should not be used in arriving at a depletion curve (New Mexico Exhibit 54, P.106). It is primarily a matter of engineering judgment as to whether or not a data point is a "sport" and should be excluded from further consideration. The Technical Assistant concludes that 1928 is a "sport" and should be excluded.

The Technical Assistant finds that it is rational to exclude the 1928, 1942, 1944, and 1945 data points and recommends that the "Review of Basic Data" depletion relationship as proposed by New Mexico be accepted by the Master. Good engineering judgment was utilized in excluding the four data points. The equity argument also supports this recommendation. *-12-*

HOW SHOULD ARTESIAN INFLOW BE DETERMINED BETWEEN ACME AND ARTESIA?

New Mexico proposes the use of the "Review of Basic Data" method for determining the artesian inflow between Acme and Artesia. Texas developed a correlation among water levels in four wells, precipitation and artesian inflow (base flow gain). Artesian inflow is basically the groundwater contribution to the river between Acme and Artesia.

The Texas procedure for determining artesian inflow is described by the Texas witness, Mr. Klempt, in his testimony and also in Texas Exhibit 67. Texas used statistical procedures to derive a correlation equation expressing the relationship among artesian inflow, precipitation, and the measured water levels in four wells. Three of the wells selected are artesian wells and one well is a shallow well. Based on hydrologic principles, water flows from the shallow and artesian aquifers to the river because the water level in each aquifer is higher than the water level in the river. As the water level increases in the aquifer, the rate of artesian inflow to the river increases. The water level in these aquifers was described by Texas using the term "head on the aquifer" (Texas Exhibit 67, P.1). Water levels in the aquifers are affected by recharge from precipitation and pumping. Texas obtained a correlation relationship utilizing the data available between 1938 and 1946.

New Mexico utilized as their witness concerning this issue, Mr. Flook. Mr. Flook is the individual who prepared the "Review of Basic Data" – "Appendix 8 – Base Inflow – Acme to Artesia." Mr. Flook testified concerning the procedures he used to derive his relationship between precipitation and artesian inflow. He also presented his report which analyzes Texas Exhibit 67 (New Mexico Exhibit 57). Mr. Flook correctly pointed out several fatal problems associated with the Texas analysis.

In order to derive a correlation between water levels, precipitation and base flow gain, Texas necessarily assumed that as water levels increase, base flow gain

increases, and as water levels decrease, base flow gain decreases. This is a logical and realistic assumption. However, the correlation obtained indicates by the negative coefficient for the Artesia and Cumberland water levels, that base flow increases with decreasing water levels (Texas Exhibit 7, P.6). This is contrary to reality and contradicts the original assumption (New Mexico Exhibit 57, P.10). Mr. Charnes would have classified this as a failure to objectively restrict the correlation equation used to forms consistent with hydrological reality (Texas Exhibit 41a, P.51). Mr. Flook properly characterized the Texas analysis as follows:

> "I have a problem with both precipitation the way it was used and the well levels. The well levels are, of course, subject to level modification during the summer when pumping is done. In the Texas study it also shows that of the four wells, two of the wells, and I believe they are Cumberland and Artesia, show a negative correlation parameter, which simply means that the lower the well level the lower the base inflow.
>
> Now this is one of the absurdities we get into, and it is the one that Dr. Charnes explained that we would not allow an equation like this to be considered in the competition for a curve to be selected because it is nonsensical to say if we pumped Artesia, the Artesia well, and Cumberland well much harder, that we should get more flow, more base flow into the Pecos River. All of the parameters should be plus if it is to be a believable correlation" (Transcript P.4328-4329).
>
> "The unprecedented precipitation in 1941 combined with the above average precipitation in 1941 had a major effect on base inflows in those years and for several years thereafter, including 1946. To include these unusual precipitation years and their after effects in a short nine year study period is not rational. To include these

unusual precipitation years in a five year moving average for a nine year study period is clearly unacceptable" (New Mexico Exhibit 57, P.2).

"The inclusion of the unprecedented precipitation biases the equation" (New Mexico Exhibit 57, P.11).

Mr. Flook also testified that the effects of groundwater storage resulting from the 1941 and 1942 flood years are evident in the well hydrographs until about 1949 or 1950 (Transcript P.4334).

Although Mr. Klempt examined the water level records for several wells in the area, he did not make any comparisons or establish whether or not the four selected wells are representative of the area-wide water levels (Transcript P.4386). Mr. Flook testified that generally, in his experience, there is great difficulty in adequately measuring area-wide groundwater table levels (Transcript P.4307). Mr. Flook also stated that an accurate history of the area-wide groundwater levels does not now exist and that there are problems associated with using the Artesia well to represent water levels because it is a pumped well (New Mexico Exhibit 57, P.6).

The Technical Assistant concurs generally with Mr. Flook's criticism of the Texas analysis. The problems pointed out by Mr. Flook are indeed fatal to the Texas analysis. Therefore, the Technical Assistant recommends that the Master reject the Texas analysis of artesian inflow.

In the "Review of Basic Data," Mr. Flook used the 1937-1941 and 1949-1957 time periods to establish the 1947 condition of the precipitation – artesian inflow relationship. The mid-points of these time periods (1940 and 1954) are identically seven years before and after 1947. The obvious question and objection is whether or not data from the years 1949-1957 can be used to represent the 1947 condition artesian inflow. Another question is whether or not data that is influenced by the unprecedented flood years (1942-1948) should be excluded. Both of these questions can be answered by referring to New Mexico Exhibit 57,

Figure 1. The figure shows a cumulative plot of base inflow (artesian inflow) for the years 1919-1977. The figure also shows the effect of the 1941 precipitation on artesian inflow for the period 1941-1948. If the 1941-1948 time period is used in the analysis, the artesian inflow will be overestimated for "normal" years and the 1947 condition. The Technical Assistant concurs with Mr. Flook and the "Review of Basic Data" that the years 1942-1948 should be excluded in order to determine the 1947 condition artesian inflow. The slope of the lines connecting the 1937-1941 and the 1949-1957 data points are identical. Because the slopes are identical, use of data from the 1949-1957 period will not bias the results. After 1957, the slope of the data points changes and it certainly would not be appropriate to use data after 1957. In other words, essentially the same relationship should result whether an engineer uses the data for the 1937-1941 period alone or for the combined periods of 1937-1941 and 1949-1957.

The Technical Assistant finds that the Texas analysis of artesian inflow has several fatal deficiencies and that the relationship developed by Texas for estimating the 1947 condition artesian inflow must be rejected. The relationship developed by Mr. Flook as described in the "Review of Basic Data" (Appendix 8) and as proposed by New Mexico reasonably describes the artesian inflow between Acme and Artesia. The "Review of Basic Data" procedure using precipitation as presented by New Mexico should be used to determine artesian inflow. *–16–*

RECOMMENDED FINDINGS AND CONCLUSIONS

The findings of the Technical Assistant have been described under each of the issue headings. The Technical Assistant respectfully recommends that the Master adopt these findings as his own and render a decision accordingly.

Concerning the major issues, the Technical Assistant concludes as follows:

1. Negative flood inflows should be retained and added algebraically when determining the annual flood inflows, except where they are demonstrably the result of lag effect. Adjustments should be made for lag effect.
2. To determine river losses between Artesia and Damsite No. 3, it will be necessary to derive a new relationship retaining the data points eliminated by Texas and by grouping together the data points that are suspect of being affected by lag. The maximum monthly loss should be 14,300 acre-feet.
3. The correct monthly distribution of the annual irrigation demand for the Carlsbad Project should be 11 months with no diversions in November.
4. It is appropriate to exclude the data points affected by the unprecedented rains of 1941 and 1942 in determining the 1947 condition river flows. The "Review of Basic Data" depletion relationship as proposed by New Mexico is acceptable.
5. The "Review of Basic Data" procedure using precipitation as presented by New Mexico should be used to determine artesian inflow. *–17–*