Appendix 2.

Evaluation Notes and Calculations

(1) North of Δ Storage, Surface
Preliminary Evaluation of Smrs 9/21/95
Res storage vs Pumping Capacity

Zero N of Δ GW
Zero Δ Storage
Delta Conv 7500
Water Supply factor 0
Env. Factor 1.0

Table: Env Outflow TAF

North of Δ	Conveyance				
Storage	1000	2000	3000	4000	5000
500	167				
1000	194				
1500	205		457		537
2000	212				
3000	212				593

This table serves as a check on spreadsheet. Benchmark post process spreadsheet was revised slightly.

This run fully exercizes north of Delta storage for environmental purposes.

Conclusion:

Yield	Storage	Pump Capacity	index $/AF
300 TAF	750	2,000 cfs	$.18
400 TAF	800	3,000 cfs	.19
500 TAF	1200	4,000 cfs	.21

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	B	C	D	E	F	G	H	I	J	K
4	Groundwater Storage Data									
5										
6	**North of Delta Facilities**			**South of Delta Facilities**				**Non-Project Recharge Rate**		
7										
8	Recharge Rate (CFS)	500		Recharge Rate (CFS)	500			**Deficit**	**Storage**	**Rate**
9	Extraction Rate (CFS)	1000		Extraction Rate (CFS)	1000			1	0	0.0215
10	Maximum Storage (TAF)	~~500~~	0	Maximum Storage (TAF)	350			0.77	115	0.0166
11	Starting Storage (TAF)	~~300~~	0	Starting Storage (TAF)	200			0.63	185	0.0143
12	Extraction Ratio [1]	Not Used		Extraction Ratio [2]	0.9			0.53	235	0.0117
13	Water Supply Factor	0.5								
14	Environmental Factor	0.5						0.46	270	0.0095
15	[1] Percent of Offstream Storage to Begin Extraction			[2] Percent of Offstream Storage to Begin Extraction				0.41	295	0
16										
17	Offstream Storage Data							**SWP Distribution Pattern**		
18										
19	**North of Delta Storage**			**South of Delta Storage**				OCT	217.5	0.070
20								NOV	203.3	0.065
21	Conveyance to (CFS)	~~3000~~	very	Conveyance to (CFS)	Limited [3]			DEC	206.4	0.066
22	Conveyance from (CFS)	~~5000~~		Conveyance from (CFS)	Limited [3]			JAN	189.5	0.061
23	Maximum Storage (TAF)	~~1500~~		Maximum Storage (TAF)	850			FEB	193.5	0.062
24	Starting Storage (TAF)	500		Starting Storage (TAF)	250			MAR	218.2	0.070
25	Water Supply Factor	~~0.5~~	0					APR	249.9	0.081
26	Environmental Factor	~~0.5~~	1	[3] Limited only by Aqueduct Capacity.				MAY	285.4	0.092
27								JUN	349.6	0.113
28								JUL	361.7	0.117
29	**In-Delta Storage**				**Ecosytem Demand**			AUG	357.0	0.115
30					**Target Delta Outflow**			SEP	272.4	0.088
31	Conveyance to (CFS)	5000			**(CFS)**					
32	Conveyance from (CFS)	5000			OCT	7000		Total	3104.4	1.000
33	Maximum Storage (TAF)	~~200~~	0		NOV	7000				
34	Starting Storage (TAF)	~~100~~	0		DEC	7000				
35					JAN	7000				
36					FEB	7000				
37					MAR	7000				
38	**In-Delta Storage**				APR	7000				

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	B	C	D	E	F	G	H	I	J	K
39	Minimum Storage to Extract for Exp. (TAF)				MAY	7000				
40	Factor				JUN	7000				
41	OCT	200	1		JUL	7000				
42	NOV	200	1		AUG	7000				
43	DEC	200	1		SEP	7000				
44	JAN	200	1							
45	FEB	200	1							
46	MAR	200	1							
47	APR	200	1							
48	MAY	180	0.9							
49	JUN	160	0.8							
50	JUL	140	0.7							
51	AUG	120	0.6							
52	SEP	100	0.5							
53										
54										
55	Delta Conveyance (CFS)	7500								

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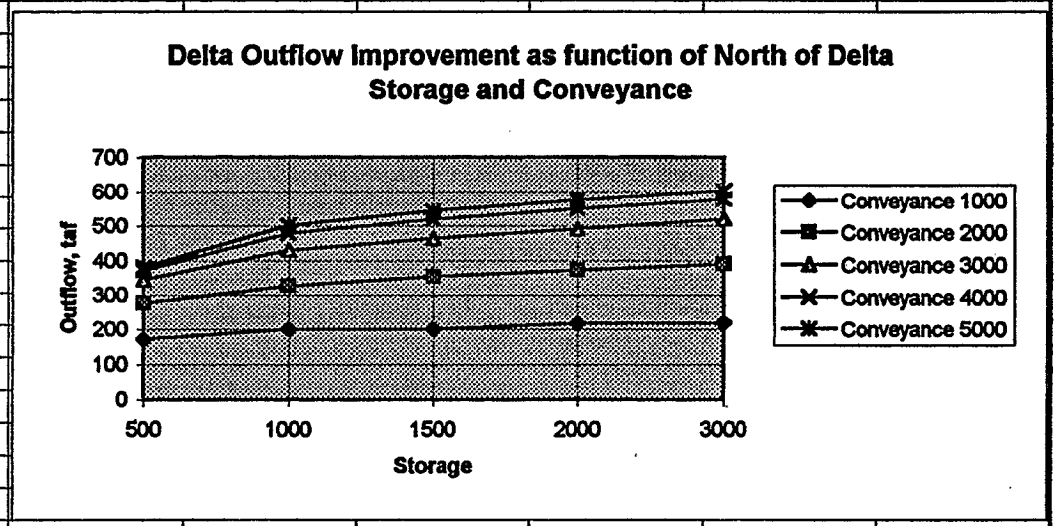
SMB 9/19/96

North of Delta Storage	Conveyance 1000	Conveyance 2000	Conveyance 3000	Conveyance 4000	Conveyance 5000
500	172	278	345	373	381
1000	200	328	430	478	501
1500	200	355	464	519	545
2000	218	372	491	550	577
3000	221	390	519	578	603



Outflow Increment	Required Storage,taf	Required conveyance, cfs	Storage Cost, $million/yr	Conveyance Cost	Net Cost/Outf
200	1500	1000	$30	$21	$0.25
300	750	2000	$12	$41	$0.18
400	600	5000	$10	$104	$0.28
400	650	4000	$11	$83	$0.23
400	800	3000	$13	$62	$0.19
400	3000	2000	$98	$41	$0.35
500	1000	5000	$17	$104	$0.24
500	1200	4000	$20	$83	$0.21
500	2100	3000	$45	$62	$0.21
600	3000	5000	98.1	103.7	$0.34

Minimum cost combos:	storage	conveyance
	750	2000
	800	3000
	1200	4000
	~~2100~~	~~3000~~

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(2) North of Δ Storage, Surface Reservoir Storage vs Pumping Cap. SMB 9/21/96

Zero N of Δ GW
Zero Δ Storage
Delta Conveyance 7500
Water Supply factor 0.5
Env Factor 0.5

Table: Env. Outflow + Σ Exports

North of Δ Storage	Conveyance 1000	2000	3000	4000	5000
500	453	545	603	636	650
1000	479	597	698	774	832
1500	488	630	740	834	904
2000	491	652	769	867	947
3000	493	674	813	917	1001

Flow Inc	Rgid Stor	Rgid Conv.	Stor Cost	Conv Cost	$M/TAF
500	3000	1000	98.1	20.8	.238
600	1000	2000	16.50	41.6	.097
600	500	3000	8.25	62.4	.118
700	640	5000	10.56	104	.164
	740	4000	12.21	83.2	.136
	1000	3000	16.50	62.4	.113 ✓
800	900	5000	14.85	104	.149
	1200	4000	19.80	83.2	.129 ×
	2500	3000	73.35	62.4	.170
900	1500	5000	29.25	104	.148
	2700	4000	83.25	83.2	.185

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Reservoir storage vs Pumping capacity — SMB — 9/21/96

For a Given storage facility, compute minimal water cost as function of conveyance:

Stor	Conv	Yield	$S	$C	Σ$	$/AF	Conv	$C (if conveyance to 1/3)	Σ$	$/AF
500	1000	453	8.25	20.8	29.0	.064	*	6.93	15.18	0.0335
	2000	479	8.25	41.6	49.8	.104		13.87	22.12	0.0462
	3000	488	8.25	62.4	70.6	.145		20.8		0.0595
	4000	491	8.25	83.2	91.4	.187		27.73	35.98	0.0733
	5000	493	8.25	104	112.2	.228		34.7		
3000	1000	493	98.1	20.8	118.9	0.24	1000	6.93	105.03	0.213
	2000	674		41.6	139.7	0.21	2000	13.87		0.166
	3000	813		62.4	160.5	0.197	3000	20.8		0.146
	4000	917		83.2	181.3	0.197	*4000	27.73		0.137
	5000	1001		104	202.1	0.202	5000	34.7		0.133
	6000	1070		125			6000	41.6		0.131
2000	1000	491	48.6	20.8	69.40	.141	7000	48.5		0.1309 *
	2000	652		41.6	90.20	.138 *	8000		153.6	0.1335
	3000	769		62.4		.144	9000	62.4	160.5	0.138
	4000	867		83.2		.152				
	5000	947		104.		.161				

Conclusion:

	Conveyance Range	Use:
500 TAF	1000 cfs – 2,000 ✓	2,000 cfs
1000 TAF	3,000	3,000 cfs
2000 TAF	2000 cfs – 4,000	4,000 cfs
3000 TAF	4,000 cfs – 7,000 cfs	5,000 cfs

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	B	C	D	E	F	G	H	I	J	K
4	Groundwater Storage Data									
5										
6	**North of Delta Facilities**			**South of Delta Facilities**				**Non-Project Recharge Rate**		
7										
8	Recharge Rate (CFS)	500		Recharge Rate (CFS)	500			**Deficit**	**Storage**	**Rate**
9	Extraction Rate (CFS)	1000		Extraction Rate (CFS)	1000			1	0	0.0215
10	Maximum Storage (TAF)	500	0	Maximum Storage (TAF)	350			0.77	115	0.0166
11	Starting Storage (TAF)	300	0	Starting Storage (TAF)	200			0.63	185	0.0143
12	Extraction Ratio [1]	Not Used		Extraction Ratio [2]	0.9			0.53	235	0.0117
13	Water Supply Factor	0.5								
14	Environmental Factor	0.5						0.46	270	0.0095
15	[1] Percent of Offstream Storage to Begin Extraction			[2] Percent of Offstream Storage to Begin Extraction				0.41	295	0
16										
17	Offstream Storage Data							**SWP Distribution Pattern**		
18										
19	**North of Delta Storage**			**South of Delta Storage**				OCT	217.5	0.070
20								NOV	203.3	0.065
21	Conveyance to (CFS)	5000	vary	Conveyance to (CFS)	Limited [3]			DEC	206.4	0.066
22	Conveyance from (CFS)	5000		Conveyance from (CFS)	Limited [3]			JAN	189.5	0.061
23	Maximum Storage (TAF)	1500		Maximum Storage (TAF)	850			FEB	193.5	0.062
24	Starting Storage (TAF)	500	0?	Starting Storage (TAF)	250			MAR	218.2	0.070
25	Water Supply Factor	0.5	0					APR	249.9	0.081
26	Environmental Factor	0.5	1	[3] Limited only by Aqueduct Capacity.				MAY	285.4	0.092
27								JUN	349.6	0.113
28								JUL	361.7	0.117
29	**In-Delta Storage**				**Ecosytem Demand**			AUG	357.0	0.115
30					Target Delta Outflow			SEP	272.4	0.088
31	Conveyance to (CFS)	5000			(CFS)					
32	Conveyance from (CFS)	5000			OCT	7000		Total	3104.4	1.000
33	Maximum Storage (TAF)	200	0		NOV	7000				
34	Starting Storage (TAF)	100	0		DEC	7000				
35					JAN	7000				
36					FEB	7000				
37					MAR	7000				
38	**In-Delta Storage**				APR	7000				

Marco 9/19/96

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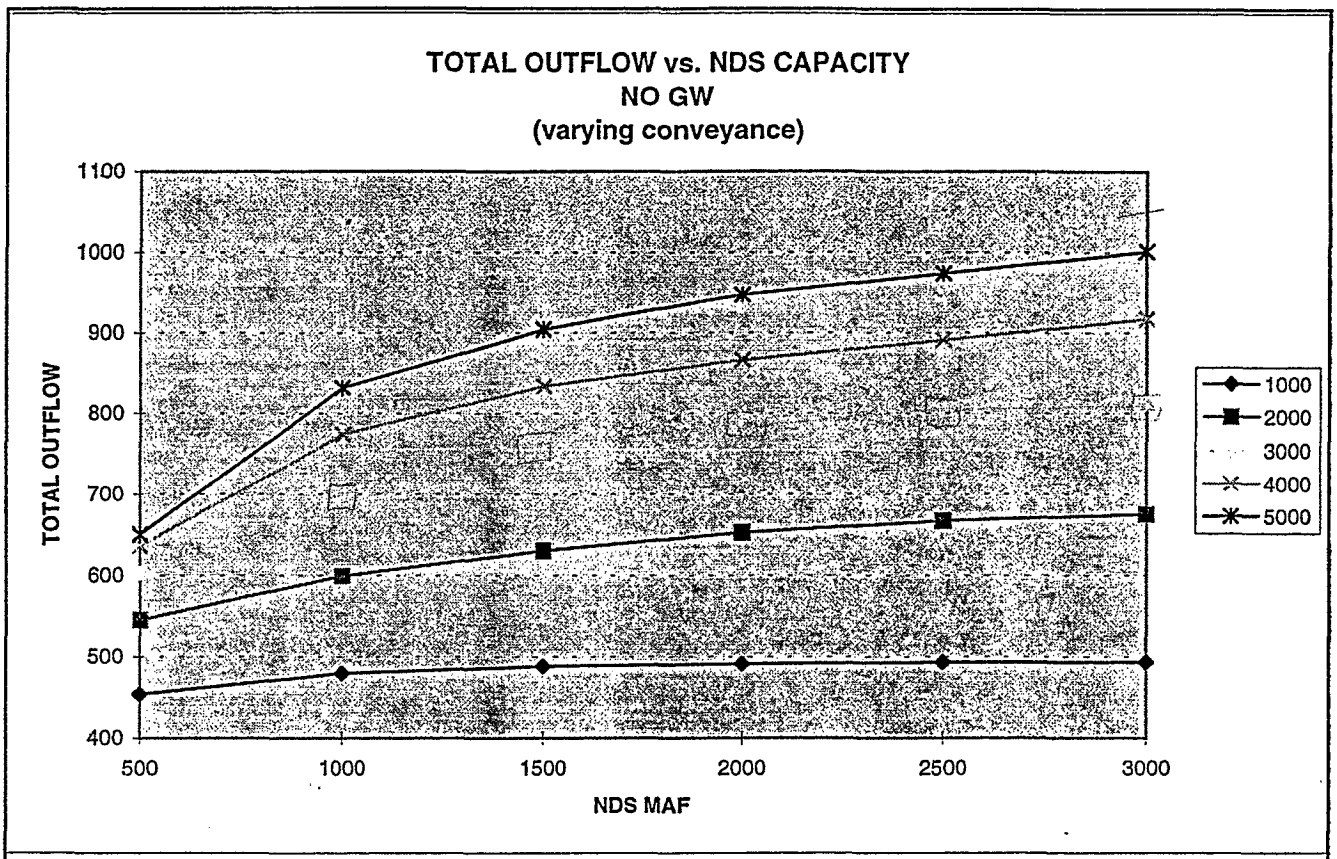
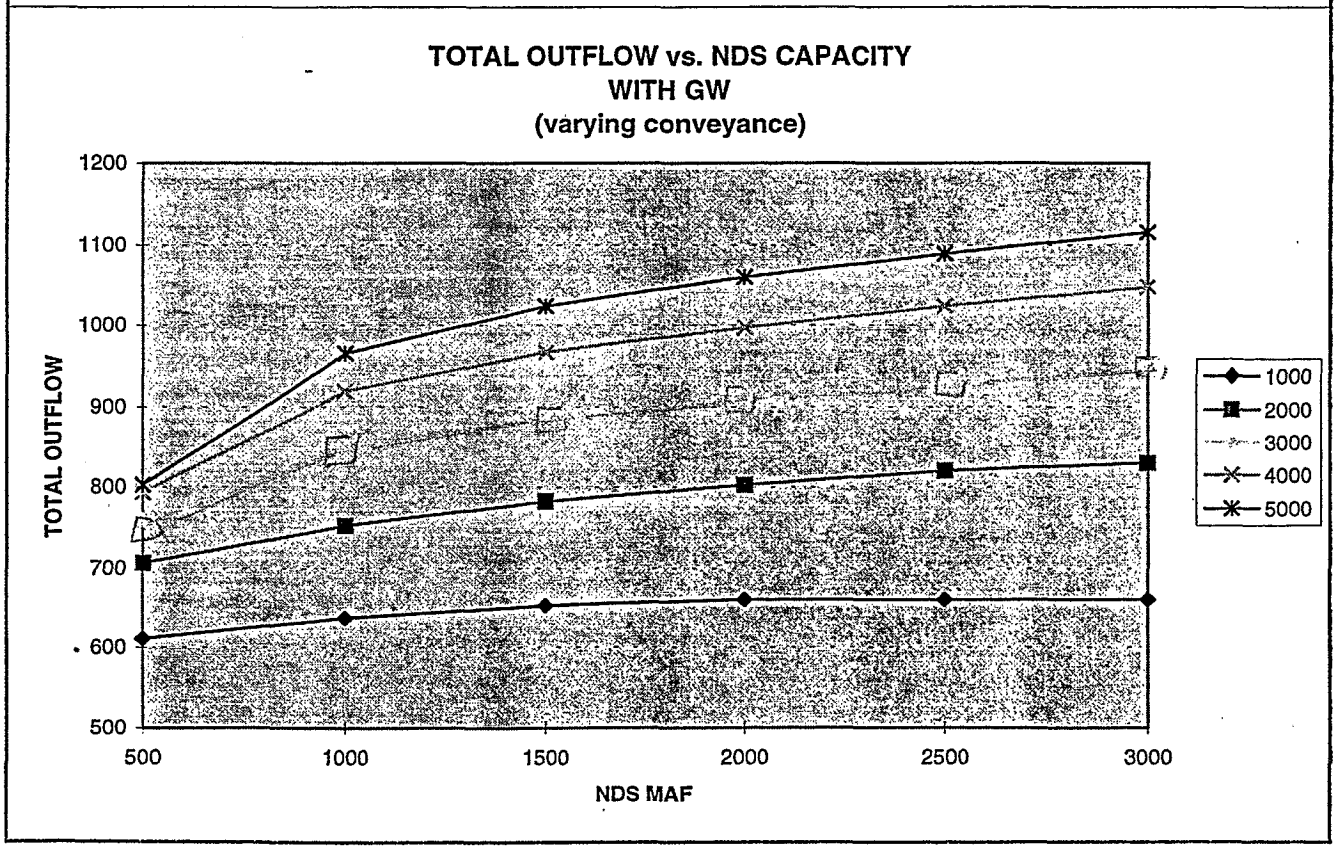

TOTAL OUTFLOW vs. NDS CAPACITY
NO GW
(varying conveyance)
TOTAL OUTFLOW
NDS MAF
1100
1000
900
800
700
600
500
400
500
1000
1500
2000
2500
3000
1000
2000
3000
4000
5000


TOTAL OUTFLOW vs. NDS CAPACITY
WITH GW
(varying conveyance)
TOTAL OUTFLOW
NDS MAF
1200
1100
1000
900
800
700
600
500
500
1000
1500
2000
2500
3000
1000
2000
3000
4000
5000

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Environmental Factor .5 Water Supply .5
Ground water storage and In Delta Storage **OFF**

Outflow+Exports (no gw)

Conv.	NDS===>>> 500	1000	1500	2000	2500	3000
1000	453	479	488	491	493	493
2000	545	599	630	652	666	674
3000	603	698	740	769	792	813
4000	636	774	834	867	891	917
5000	650	832	904	947	974	1001

Environmental Factor .5 Water Supply .5
Ground water storage **ON** and In Delta Storage **OFF**

Outflow+Exports (+ gw)

Conv.	NDS===>>> 500	1000	1500	2000	2500	3000
1000	611	637	653	661	661	661
2000	707	753	783	803	820	830
3000	760	850	883	909	932	951
4000	794	919	967	997	1024	1048
5000	803	965	1024	1060	1089	1116

NDS	$M/yr.
1200	19.8
1800	38.7
3000	98.1

Combine Facily Cost ($M/yr.)

Conv.	NDS===>>> 500	1000	1500	2000	2500	3000		Forecasted Cost	
1000	$33	$36	$51	$71	$96	$121	$21	500	($14)
2000	$53	$56	$71	$91	$116	$141	$41	1000	$8
3000	$74	$77	$92	$112	$137	$162	$62	1500	$30
4000	$95	$98	$113	$133	$158	$183	$83	2000	$52
5000	$116	$119	$134	$154	$179	$204	$104	2500	$74
	$12	$15	$30	$50	$75	$100		3000	$97

NET COST / WATER - Outflow+Exports (no gw)

Conv.	NDS===>>> 500	1000	1500	2000	2500	3000
1000	0.07	0.08	0.10	0.14	0.19	0.25
2000	0.10	0.09	0.11	0.14	0.17	0.21
3000	0.12	0.11	0.12	0.15	0.17	0.20
4000	0.15	0.13	0.14	0.15	0.18	0.20
5000	0.18	0.14	0.15	0.16	0.18	0.20

			NET COST / WATER - Outflow+Exports (+ gw)						
	NDS===>>>								
Conv.	643 500	1000	1500	2000	2500	3000			
1000	0.05	0.06	0.08	0.11	0.15	0.18			
2000	0.07	0.07	0.09	0.11	0.14	0.17			
3000	0.10	0.09	0.10	0.12	0.15	0.17			
4000	0.12	0.11	0.12	0.13	0.15	0.17			
5000	0.14	0.12	0.13	0.15	0.16	0.18	647		

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Project Conveyance / Storage — Sheet a
Feature North of Delta Surface — Designed SMB — Date 9/28/96
Item — Checked — Date

▶ How does No Δ gw storage affect break pt. in surface storage curve? Compute gradient in No Δ surface curve, @ 500 TAF and 1,000 TAF

No Δ SS w/ GW (P.1,2,3)			No Δ SS alone (P.8,10,11)			
St	Su	d Supply / d Storage	St	Supply	d Supply / d Stor	
1000	279	.065	1000	440	.070	Avg of whole record
800	266	.070	800	426	.120	
600	252	.155	600	402	.395	
400	221	~~~~	400	323	~~~~	
1500	319	.142	1500	343	.140	Dry period Avg
1000	248	.145	1000	272	.140	
800	219	.145	800	244	.145	
600	190	.140	600	215	.145	
400	162	.270	400	186	.320	
200	108		200	122		

Conclusions:

- For average of whole record adding groundwater storage causes supply curve for reservoir to level off sooner: at 400 TAF rather than 800 TAF storage
- For Dry period average, adding groundwater storage causes supply curve for reservoir to level off later – at 3,000 TAF rather than 2500 TAF.

This indicates that surface and gw storage compete to some extent with each other for

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Project _____ Sheet 6

Feature _____ Designed _____ Date _____

Item _____ Checked _____ Date _____

annual yield. However, gw storage allows for retention of larger critical period supplies in SS.

- Conclusion upper limit for north of Δ storage, with existing conveyance, is 3,000 TAF.

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Project Conveyance / Storage Sheet C
Feature Delta Storage Designed SMB Date 9/28/96
Item Checked Date

How does north of Δ surface and gw storage affect in Delta storage?

Compare in Δ storage alone with in Δ storage plus n Δ SS and N Δ gw.

With in-Delta storage alone, (P.7), Yield levels of smoothly, but continues to gain at 700 TAF. With 3,000 TAF SS + 500 TAF GW, the yield from IN Δ storage is 0 TAF for SWP. However yield from in Δ storage for outflow is 265 TAF, (vs 279 on P7)

This indicates that in Δ storage provides additional opportunities to capture surplus flows (almost undiminished yield) but export capabilities or demand limit exports from delta.

(Figures from Sb-Exist.xls → Cr_buer.xls

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Project Conveyance / Storage Sheet d
Feature North of Delta Surface Designed SMB Date 9/28/96
Item Checked Date

▶ How does dual use of N of Δ surface water storage affect break point in surface storage curve?

We have explored single component curve for SWP = 1 (P. 8), ENV = 1 (P. 13). Inspection of these two graphs suggests that break points in curves shift very little, although absolute value for env=1 curve is higher. Thus I would expect that 50/50 split would look similar but demand would be higher. Inspection of p 17 confirms that major break point is still in 800 - 1,000 TAF range, with secondary break point ~ 3,000 TAF. See p. 18, p 19 (19 is same as 18, but with data points for 4,000 TAF and 5,000 TAF added.

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Project Conveyance / Storage Sheet e

Feature South of Δ Surface Designed SMB Date 9/29/96

Item Checked Date

▶ How does improved Delta conveyance affect break point in S of Δ surface storage curve. Zero out other storages. Water supply factor = 1.0, Conveyance set to 10,300

☐ Why doesn't spreadsheet show gain in yield from add'l conveyance alone?
Compare P. 6 to P. 19. With existing conveyance break point is in the vicinity of 400-500 TA storage. With improved conveyance, break point shifts to about 1500 TAF.

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Project Conveyance / Storage Sheet f

Feature South of Δ Surface Designed SMB Date 9/29/96

Item Effect of Adding GW Checked Date

How does adding GW south of Δ affect surface storage? To find out, add maximum GW and examine impact on surface storage curve.

Compare P. 20 and P. 21. The results show that there is significant change in the breakpoint for the surface storage vs supply curve. ~~It also~~ It shows that south of Delta surface and gw storage compete for available supplies, as gw storage declines with increasing surface storage.

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Project Conveyance / Storage Sheet 2
Feature South of Δ Surface + GW Designed SMR Date 9/29/96
Item Effect of North of Δ Storage Checked Date

▶ How does adding North of Delta, Surface and GW, affect South of Delta Surface Storage Curve?

Compare South of Delta Surface Storage alone (P.20) to adding all other storages, except in-Delta, (p 22).

The result: The other available storages in system reduce gradient of $\frac{d\ \text{Supply}}{d\ \text{Storage}}$. Data tabulated below, and plotted on p 24. Example: for a storage of 670 TAF, gradient is $\frac{0.4\ \text{TAF Supply}}{1.0\ \text{TAF Storage}}$ for

Gradient, South of Delta Storage, with all others except in-Delta		
So'D stor	Supply	dy/dx
0	0	
200	142	0.7100
400	203	0.3050
600	231	0.1400
800	251	0.1000
1000	265	0.0700
1500	297	0.0640
2000	318	0.0420
2500	334	0.0320
3000	346	0.0240

Gradient, South of Delta Storage, with no other storages on line		
So'D stor	Supply	dy/dx
0	0	
200	270	1.3500
400	394	0.6200
600	483	0.4450
800	543	0.3000
1000	586	0.2150
1500	652	0.1320
2000	694	0.0840
2500	735	0.0820
3000	763	0.0560

South of Delta Storage alone. With other storages on line, that gradient is reached at 360 TAF. Thus a smaller reservoir is economically justified.

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