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Appendix

Appendix

SUPPORTING DATA

Information for Tables A-1 through A-6 was derived as part of the Irrigation Water Management Study and is included on the following pages as supporting data. Table A-1 provides the Prairie Provinces Water Board return flow estimates used in compiling data on water losses. Table A-2 presents a summary look at agro-climatic and crop type data used in the Farm Financial Impact and Risk Model. Tables A-3 through A-6 present irrigation water demand and deficit analyses used in the Irrigation District Model and/or the Water Resources Management Model.

DETAILED ASSESSMENT OF EXPANSION SCENARIOS

A total of 10 irrigation scenarios was modelled as part of the Irrigation Water Management Study. Details on four key scenarios are given in the body of this volume. Histograms showing the variation in weighted-average irrigation demand, bar graphs showing the frequency of irrigation deficits, and line graphs showing the areal extent of irrigation deficits modelled for the other six scenarios are presented here (Figures A-1a through A-12b). As in Chapter VI, distinct graphics are shown for the Bow Basin districts and the Oldman Basin districts.

Table A-1. Summary of Prairie Provinces Water Board (PPWB) return flow estimates (dam^3) from 1985 to 2000[1] .

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Mean
BRID	84,284	82,440	84,284	103,111	101,550	101,692	105,100	114,167	101,125	99,395	69,880	80,138	77,322	76,451	72,439	77,423	89,425
EID	251,709	263,619	211,448	202,382	227,387	246,869	269,340	284,610	202,002	239,913	270,647	243,952	271,340	250,195	199,406	210,648	240,341
LNID	13,867	21,983	26,530	27,234	25,081	31,642	37,734	38,051	28,669	38,580	32,273	38,502	35,600	39,905	41,428	35,500	32,036
MVLA[2]	16,196	9,602	12,899	17,891	7,999	6,184	7,587	15,755	2,822	7,506	3,641	7,181	7,141	9,297	10,644	22,516	10,303
SMP, MID[3]	98,864	151,146	116,932	101,597	89,901	93,789	127,623	121,968	162,054	117,397	116,708	142,889	103,488	139,616	95,593	67,215	115,424
UID	14,806	11,409	14,574	19,175	11,290	7,337	9,000	13,166	4,021	8,448	3,276	9,694	9,002	5,482	13,419	26,678	11,300
WID[4]	68,284	92,459	66,447	77,296	62,643	73,545	70,910	87,916	72,881	62,350	67,262	73,026	90,322	93,647	81,885	77,319	76,137
Totals	548,010	632,658	533,114	548,686	525,851	561,058	627,294	675,633	573,574	573,589	563,687	595,382	594,215	614,593	514,814	517,299	574,966

[1] All 1985 to 1992 data, except highlighted data, taken from PPWB report (PPWB 1995).
Highlighted data computations based on PPWB equations and methodology.
All 1993 to 2000 data obtained directly from Jim Chen, P.Eng., PPWB.
Some return flow estimates may be based on Water Survey of Canada provisional data.
[2] MVLA includes MVID, LID and AID.
[3] SMP includes SMRID, RID and TID. The PPWB estimates the total return flow from SMP and MID together.
[4] For the WID, April data are excluded from the estimates.

Table A-2. Agro-climatic and crop regions for farm enterprise types considered in the FFIRM analysis.

Climate and Crop Region	Farm Enterprise Type	Crops (% of farm area)										
		Alfalfa	Silage Barley	Tame Grass	HRS Wheat	Durum Wheat	Soft Wheat	Barley	Canola	Sugar Beets	Dry Beans	Potato
UID/MID area -225 ha farm unit	U1 Grain and forage mix	25			30			25	20			
	U2 Forage mix	40		30				30				
Lethbridge area LNID RID SMRID-W -300 ha farm unit	L1 Grain and oilseed mix					20	20	40	20			
	L2 Sugar beet mix	30					20	30		20		
	L3 Grain and forage mix	25	25				25	25				
	L4 Forage mix	30	20	30		20						
Burdett area TID SMRID-E -360 ha farm unit	B1 Grain and oilseed mix					20	20	40	20			
	B2 Sugar beet mix	30						30		20	20	
	B3 Potato mix						25	25	25			25
	B4 Forage mix	35	30	15		20						
Enchant area BRID EID-S -325 ha farm unit	E1 Grain and oilseed mix					20	20	40	20			
	E2 Sugar beet mix	30					20	30		20		
	E3 Potato mix						25	25	25			25
	E4 Forage mix	35	30	15		20						
Strathmore area WID-W -220 ha farm unit	S1 Grain and forage mix	25			30			25	20			
	S2 Forage mix	40		30				30				
Rosemary area WID-E EID-N -325 ha farm unit	R1 Grain and oilseed mix					20	20	40	20			
	R2 Grain and forage mix	25	25				25	25				
	R3 Forage mix	30	20	30		20						

Table A-3. Summary of modelling output, 68-year weighted-mean values for all scenarios.

Scenario	Basin	Area Irrigated (ha)	Crop Irrigation Requirement[1]		On-Farm Losses[2]		District Infrastructure Losses[3]		Return Flow[4]		Gross Diversion Demand[5]	
			dam^3	mm	dam^3	mm	dam^3	mm	dam^3	mm	dam^3	mm
S1. S0C0M0P8[6]	Oldman	268,859	545,724	203	195,749	73	109,009	41	171,070	64	1,021,552	380
	Bow	221,526	468,188	211	162,952	74	169,976	77	364,350	164	1,165,466	526
	All Districts	490,385	1,013,912	207	358,701	73	278,985	57	535,420	109	2,187,018	446
S2. S9C0M0P8[6]	Oldman	296,230	595,422	201	213,286	72	112,567	38	171,813	58	1,093,089	369
	Bow	239,170	499,865	209	174,594	73	172,202	72	365,930	153	1,212,592	507
	All Districts	535,400	1,095,287	205	387,880	72	284,769	53	537,743	100	2,305,681	431
S3. S9C0M0P9[6]	Oldman	296,230	651,706	220	183,663	62	109,605	37	162,927	55	1,107,900	374
	Bow	239,170	626,625	262	169,811	71	172,202	72	298,963	125	1,267,601	530
	All Districts	535,400	1,278,331	239	353,474	66	281,807	53	461,890	86	2,375,501	444
S4. E1C0M0P8[6]	Oldman	325,853	661,482	203	188,995	58	110,790	34	172,702	53	1,133,968	348
	Bow	263,086	565,635	215	152,590	58	171,006	65	360,428	137	1,249,659	475
	All Districts	588,939	1,227,117	208	341,585	58	281,796	48	533,130	91	2,383,627	405
S5. E1C2M0P8[6]	Oldman	325,853	681,033	209	195,512	60	110,790	34	175,961	54	1,163,295	357
	Bow	263,086	594,574	226	160,482	61	173,637	66	363,059	138	1,291,752	491
	All Districts	588,939	1,275,607	217	355,994	60	284,427	48	539,020	92	2,455,047	417
S6. E1C0M2P8[6]	Oldman	325,853	658,223	202	162,927	50	107,531	33	159,668	49	1,088,349	334
	Bow	263,086	539,326	205	126,281	48	165,744	63	336,750	128	1,168,102	444
	All Districts	588,939	1,197,549	203	289,208	49	273,276	46	496,418	84	2,256,451	383
S7. E2C0M0P8[6]	Oldman	355,476	721,616	203	206,176	58	113,752	32	177,738	50	1,219,283	343
	Bow	287,003	614,186	214	166,462	58	172,202	60	364,494	127	1,317,344	459
	All Districts	642,479	1,335,802	208	372,638	58	285,954	45	542,232	84	2,536,627	395
S8. E1C0M0P9[6]	Oldman	325,853	716,877	220	202,029	62	110,790	34	166,185	51	1,195,881	367
	Bow	263,086	686,654	261	186,791	71	173,637	66	305,180	116	1,352,262	514
	All Districts	588,939	1,403,531	238	388,820	66	284,427	48	471,365	80	2,548,143	433
S9. E1C2M2P9[6]	Oldman	325,853	733,169	225	182,478	56	107,531	33	149,892	46	1,173,071	360
	Bow	263,086	697,178	265	163,113	62	168,375	64	276,240	105	1,304,907	496
	All Districts	588,939	1,430,347	243	345,591	59	275,906	47	426,132	72	2,477,978	421
S10. E2C2M2P9[6]	Oldman	355,476	799,821	225	199,067	56	106,643	30	152,855	43	1,258,385	354
	Bow	287,003	757,688	264	177,942	62	169,332	59	281,263	98	1,386,224	483
	All Districts	642,479	1,557,509	242	377,009	59	275,975	43	434,118	68	2,644,609	412

[1] The Crop Irrigation Requirement is the net amount of water required for the crop growing season to be available for crop consumption, less any precipitation received during the growing season and stored soil moisture consumed.

[2] On-farm Losses is that amount of water lost due to evaporation, un-captured runoff or deep percolation during the irrigation water application process at the farm level.

[3] District Infrastructure Losses includes that volume of water lost due to canal seepage, open-channel and reservoir evaporation, as well as conveyance system tail-water not returned to a river or creek, but is lost to end-of-system ponding and/or evaporation.

[4] Return Flow is that quantity of water that flows through a conveyance system that is composed of unused water from on-farm system downtime, unavailable base flow and/or recaptured runoff from irrigated fields, all of which is drained back to rivers and creeks in the area.

[5] The Gross Diversion Demand is the sum of the four components defined above and is that total volume of water demanded by weighted average, each year from available supply sources.

[6] Identifies scenario parameter settings. S0 = 1999 irrigation area; S9 = *Regulation* limit area; E1 = 10% area expansion; E2 = 20% area expansion; C0 = 1999 crop mix; C2 = future crop mix; M0 = 1999 irrigation system mix; M2 = future irrigation system mix; P8 = irrigation to meet 80% of crop water requirements; P9 = irrigation to meet 90% of crop water requirements.

Table A-4. IDM modelling output for Scenario S1, district breakdown of 68-year weighted-average .

Irrigation District	Hectares Irrigated	Crop Irrigation Requirement			On-Farm Losses			District Infrastructure Losses[3]			Return Flow			Gross Diversion Demand	
		dam³	mm	% of GD[1]	dam³	mm	% of GD[1]	dam³	mm	% of GD[1]	dam³	mm	% of GD[1]	dam³	mm
AID_LID[3]	2,630	3,892	148	28.2	1,762	67	12.8	763	29	5.5	7,363	280	53.4	13,780	524
BRID	80,112	160,224	200	44.1	56,879	71	15.6	28,039	35	7.7	118,565	148	32.6	363,708	454
EID	111,708	262,514	235	41.1	88,249	79	13.8	112,825	101	17.7	175,382	157	27.4	638,971	572
LNID	59,339	100,876	170	49.9	36,790	62	18.2	16,022	27	7.9	48,658	82	24.0	202,346	341
MID	6,045	7,496	124	26.1	2,781	46	9.7	5,320	88	18.5	13,118	217	45.7	28,714	475
MVID	1,420	1,136	80	34.5	625	44	19.0	355	25	10.8	1,179	83	35.8	3,295	233
SMP[4]	192,381	423,237	220	56.7	150,057	78	20.1	84,647	44	11.3	88,495	46	11.9	746,436	389
UID	7,044	9,087	129	33.7	3,734	53	13.8	1,902	27	7.0	12,257	174	45.4	26,980	382
WID	29,706	45,450	153	27.9	17,824	60	10.9	29,112	98	17.9	70,403	237	43.2	162,788	548
Total	490,385														
Weighted Mean		1,013,912	207	46.4	358,700	73	16.4	278,984	57	12.8	535,420	109	24.4	2,187,017	446

[1] % of GD = Percent of Gross Diversion (Demand).

[2] In addition to canal seepage and evaporation losses and un-captured tail-water, this volume of loss also includes reservoir evaporation for those reservoirs owned and operated within the works of respective irrigation districts. Where such internal reservoir storage is shared between two or more districts, the reservoir evaporation losses are pro-rated between these supported districts, according to their respective irrigated areas.

[3] The AID_LID represents a "virtual" single district made up of the AID and LID which are both served by a common main canal carrier and therefore are modelled as one "virtual" district.

[4] The SMP (St. Mary Project) represents a "virtual" single district made up of the RID, SMRID, and TID, all served by a common main canal carrier and therefore are modelled as one "virtual" district.

Table A-5. Ranking of IDM-WRMM modelling deficit indices for irrigation districts in the Oldman Basin.

Scenario	Gross Diversion Demand		Percent of Years with Deficits of Various Magnitudes; Rank among all Scenarios												
	dam^3	Rank[1]	>1.0 mm		>50 mm		>100 mm		>150 mm		>200 mm		>250 mm		Mean Rank[1]
			%	Rank[1]	%	Rank[1]	%	Rank[1]	%	Rank[1]	%	Rank[1]	%	Rank[1]	
S1. S0C0M0P8[2]	1,021,552	1	9.68	1	1.3	1	0.14	1	0.01	1	0.00	1	0.00	2	1.2
S2. S9C0M0P8[2]	1,093,089	3	20.67	4	6.17	3	2.32	3	0.71	4	0.18	4	0.04	3	3.5
S3. S9C0M0P9[2]	1,107,900	4	18.29	3	6.81	4	2.40	4	0.69	3	0.18	4	0.08	5	3.8
S4. E1C0M0P8[2]	1,133,968	5	21.42	5	8.60	5	3.66	5	1.22	5	0.39	5	0.08	5	5.0
S5. E1C2M0P8[2]	1,163,295	6	23.74	6	9.67	6	5.37	7	1.82	6	0.95	6	0.34	7	6.3
S6. E1C0M2P8[2]	1,088,349	2	17.40	2	5.99	2	1.69	2	0.36	2	0.08	2	0.00	2	2.0
S7. E2C0M0P8[2]	1,219,283	9	30.93	9	11.29	9	6.95	9	2.61	9	1.20	9	0.83	9	9.0
S8. E1C0M0P9[2]	1,195,881	8	28.09	8	10.86	8	6.28	8	2.03	8	0.98	7	0.59	8	7.8
S9. E1C2M2P9[2]	1,173,071	7	24.58	7	10.21	7	4.54	6	1.86	7	1.01	8	0.22	6	6.8
S10. E2C2M2P9[2]	1,258,385	10	35.48	10	12.24	10	8.67	10	4.38	10	1.58	10	1.09	10	10.0

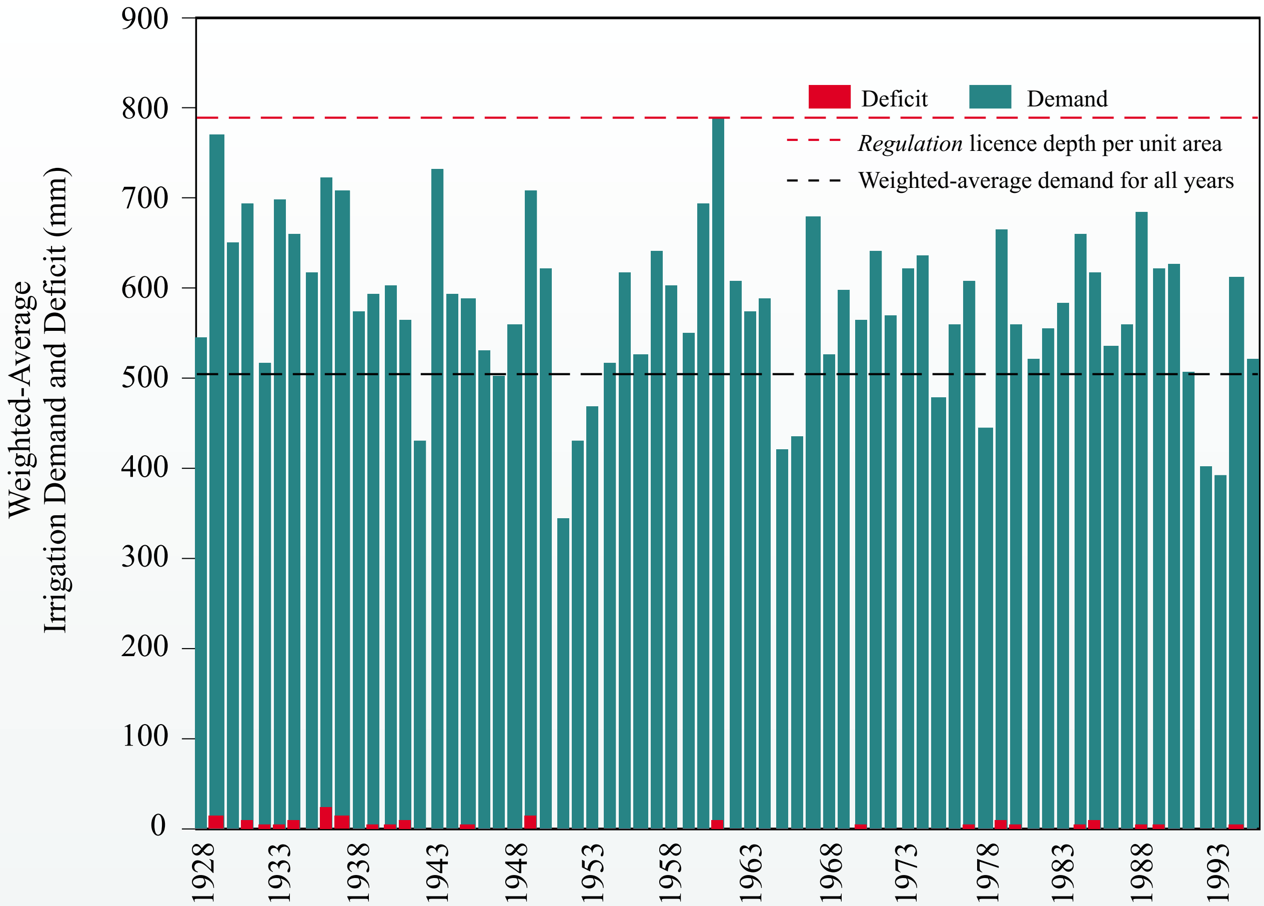
[1] Rank of 1 = Lowest level of deficits. Rank of 10 = Highest level of deficits.

[2] Identifies scenario parameter settings. S0 = 1999 irrigation area; S9 = *Regulation* limit area; E1 = 10% area expansion; E2 = 20% area expansion; C0 = 1999 crop mix; C2 = future crop mix; M0 = 1999 irrigation system mix; M2 = future irrigation system mix; P8 = irrigation to meet 80% of crop water requirements; P9 = irrigation to meet 90% of crop water requirements.

Table A-6. Ranking of IDM-WRMM modelling deficit indices for irrigation districts in the Bow Basin.

Scenario	Gross Diversion Demand		Percent of Years with Deficits of Various Magnitudes; Rank among all Scenarios												
	dam^3	Rank[1]	>1.0 mm		>50 mm		>100 mm		>150 mm		>200 mm		>250 mm		Mean Rank[3]
			%	Rank[1]	%	Rank[1]	%	Rank[1]	%	Rank[1]	%	Rank[1]	%	Rank[1]	
S1. S0C0M0P8[2]	1,165,466	1	7.67	1	0.95	2	0.24	1	0.03	1	0.00	2	0.00	1	1.4
S2. S9C0M0P8[2]	1,212,592	3	14.76	5	5.01	5	1.97	8	0.71	8	0.16	8	0.04	2	6.8
S3. S9C0M0P9[2]	1,267,601	5	14.76	5	5.01	5	1.97	8	0.71	8	0.16	8	0.04	2	6.8
S4. E1C0M0P8[2]	1,249,659	4	14.47	3	4.44	4	1.01	3	0.44	3	0.04	5	0.00	1	3.6
S5. E1C2M0P8[2]	1,291,752	6	15.79	6	5.08	6	1.39	4	0.67	5	0.04	4	0.00	1	5.0
S6. E1C0M2P8[2]	1,168,102	2	12.34	2	2.58	3	0.69	2	0.17	2	0.00	2	0.00	1	2.2
S7. E2C0M0P8[2]	1,317,344	8	16.61	8	5.31	8	1.53	5	0.67	4	0.04	3	0.00	1	5.6
S8. E1C0M0P9[2]	1,352,262	9	17.92	9	6.49	9	2.66	10	0.79	9	0.44	10	0.04	2	9.4
S9. E1C2M2P9[2]	1,304,907	7	16.11	7	5.30	7	1.83	6	0.68	6	0.13	6	0.00	1	6.4
S10. E2C2M2P9[2]	1,386,224	10	19.27	10	7.03	10	2.51	9	0.79	10	0.22	9	0.00	1	9.6

[1] Rank of 1 = Lowest level of deficits. Rank of 10 = Highest level of deficits.
[2] Identifies scenario parameter settings. S0 = 1999 irrigation area; S9 = *Regulation* limit area; E1 = 10% area expansion; E2 = 20% area expansion; C0 = 1999 crop mix; C2 = future crop mix; M0 = 1999 irrigation system mix; M2 = future irrigation system mix; P8 = irrigation to meet 80% of crop water requirements; P9 = irrigation to meet 90% of crop water requirements.
[3] Rank for deficit class >250 not included in the mean due to the number of scenarios with equal deficit probabilities.



Irrigation area = 1991 *Regulation* limit. All other variables at 1999 conditions.

Figure A-1a. Scenario S2 total demands and deficits - Bow Basin districts.

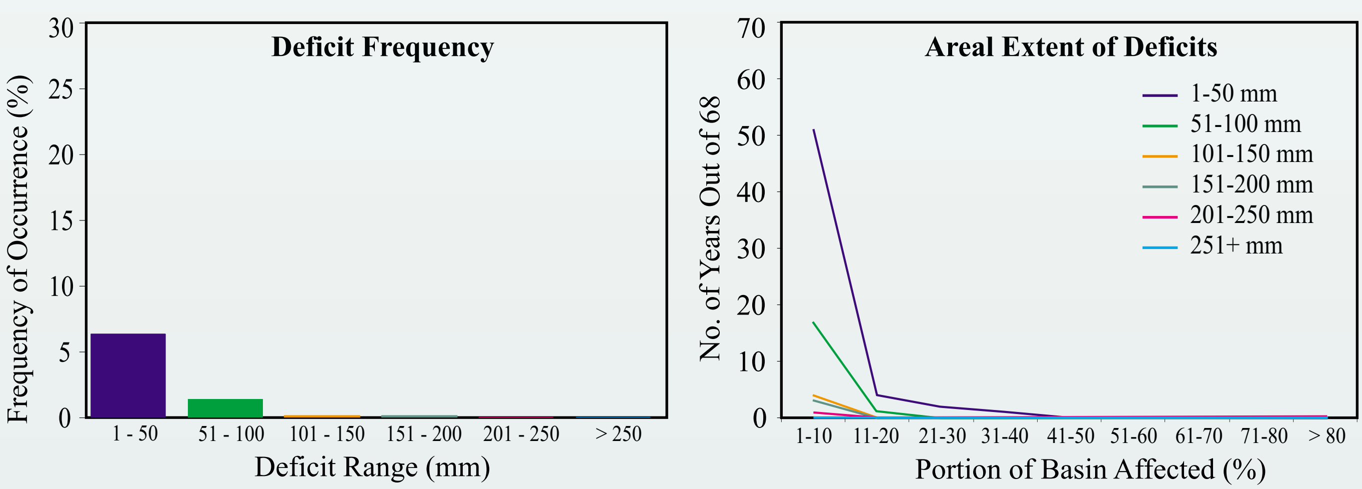
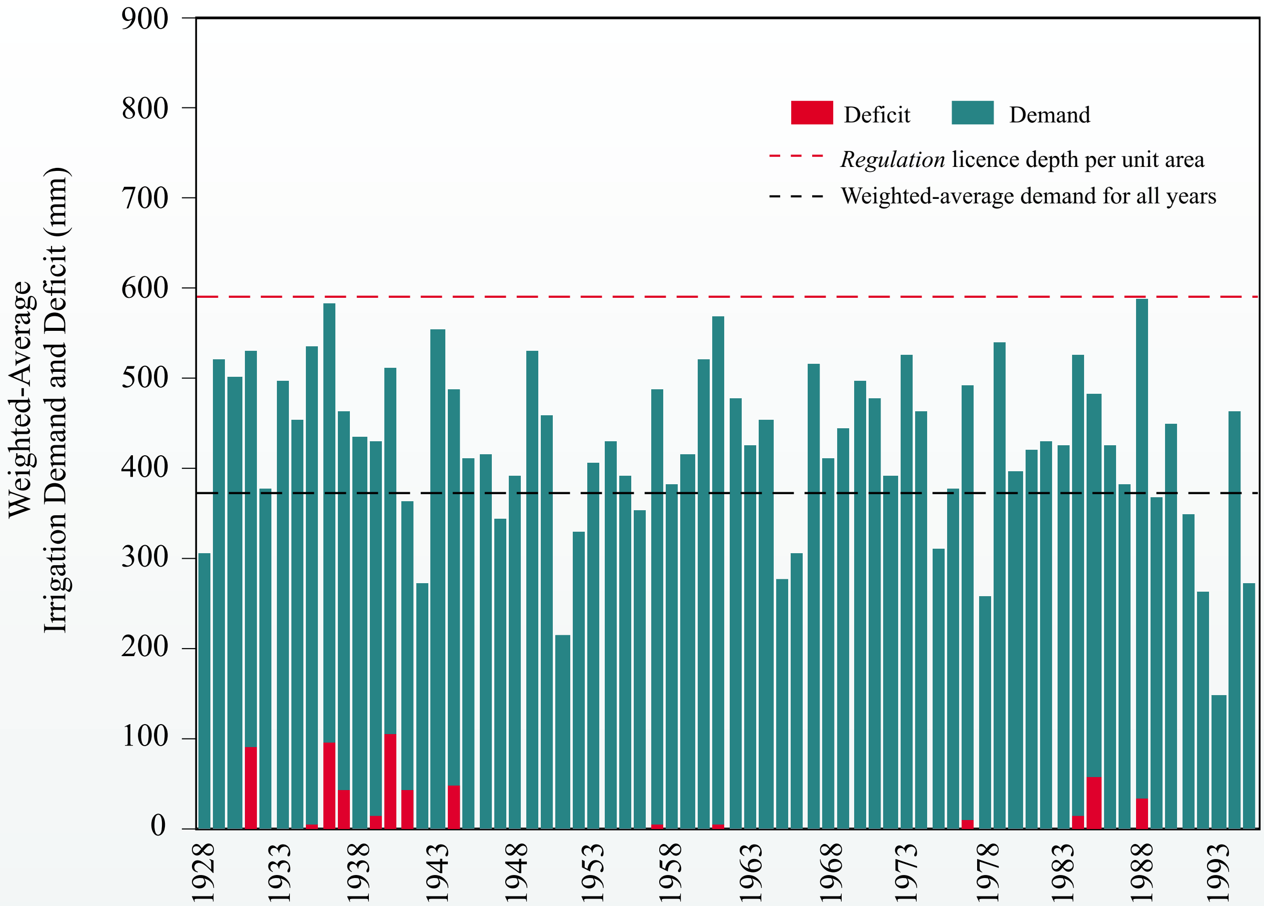


Figure A-1b. Scenario S2 irrigation deficit frequency and distribution - Bow Basin districts.



Irrigation area = 1991 *Regulation* limit. All other variables at 1999 conditions.

Figure A-2a. Scenario S2 total demands and deficits - Oldman Basin districts.

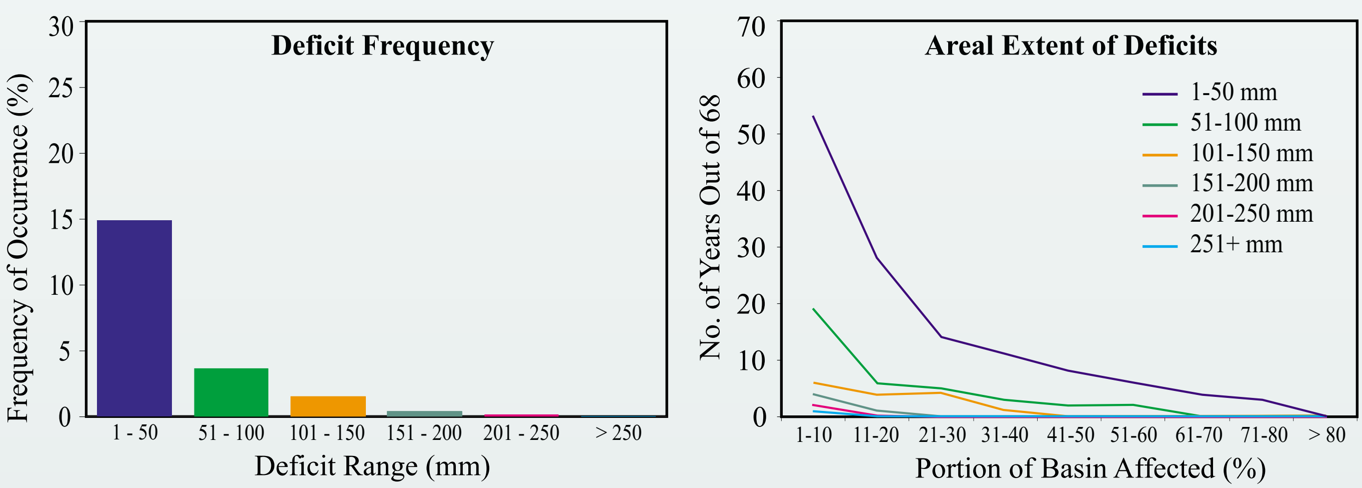
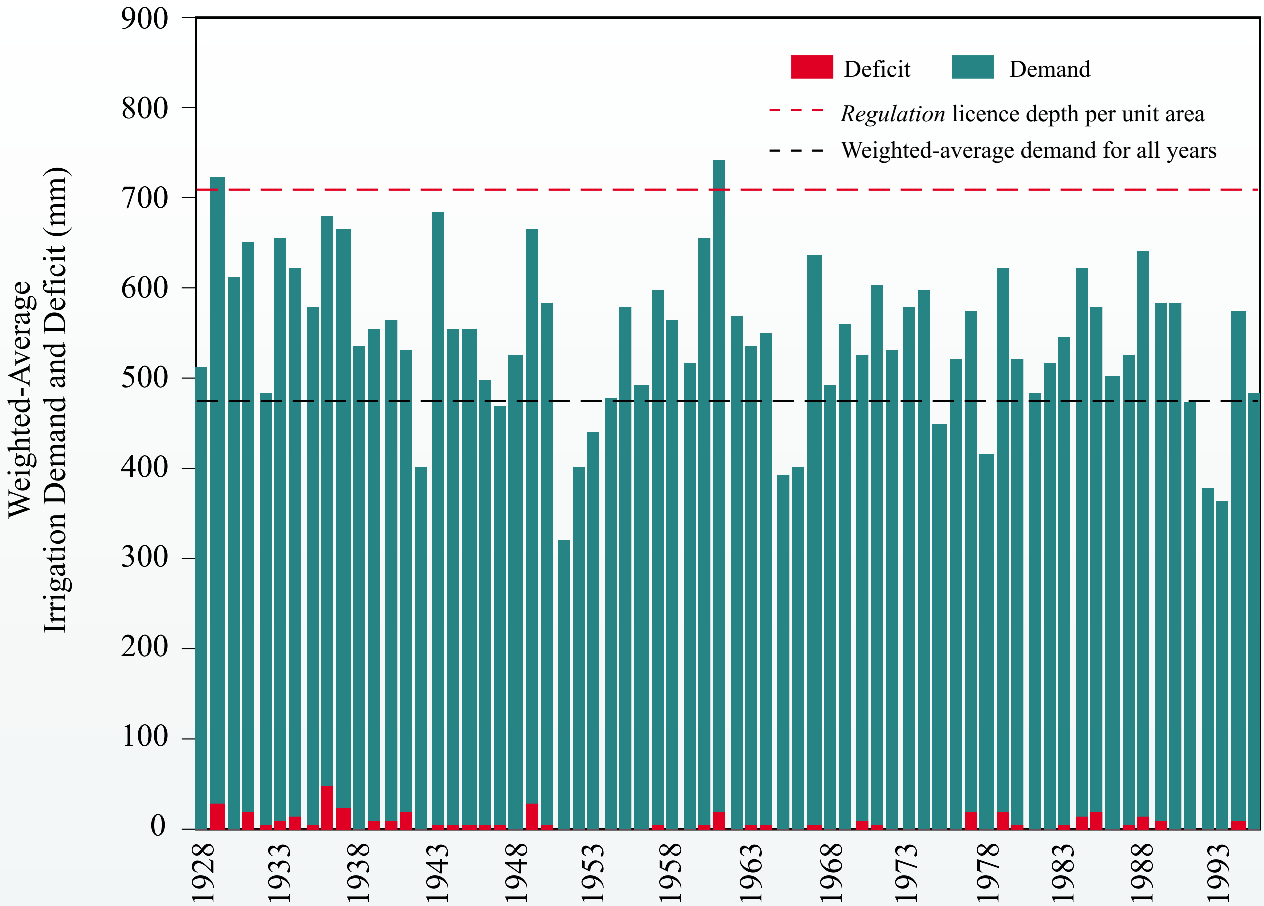


Figure A-2b. Scenario S2 irrigation deficit frequency and distribution - Oldman Basin districts.



10% expansion beyond 1991 *Regulation* limit. All other variables at 1999 conditions.

Figure A-3a. Scenario S4 total demands and deficits - Bow Basin districts.

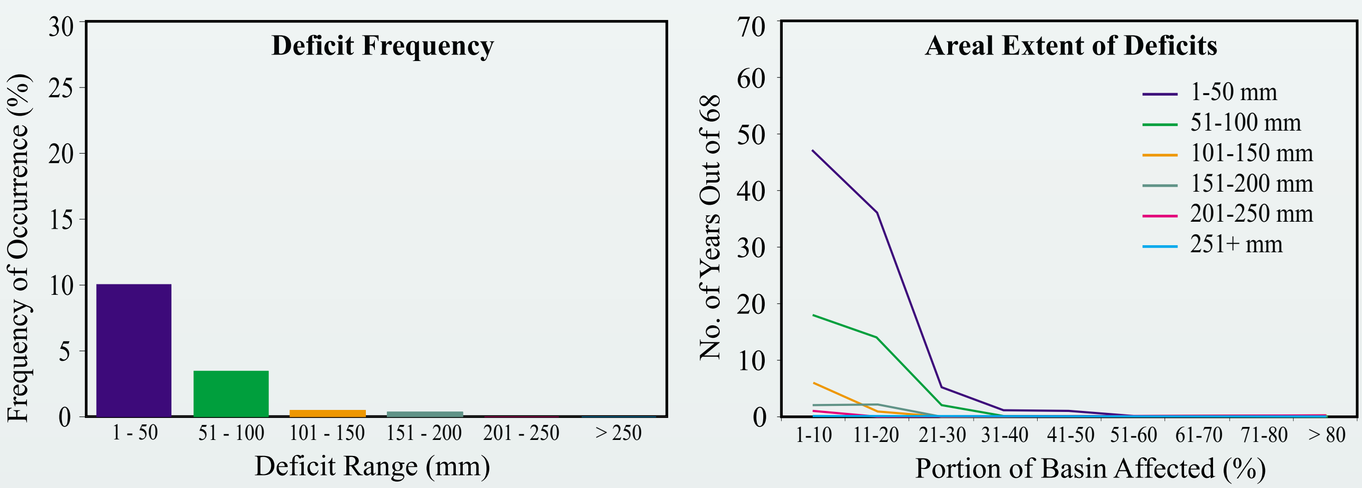
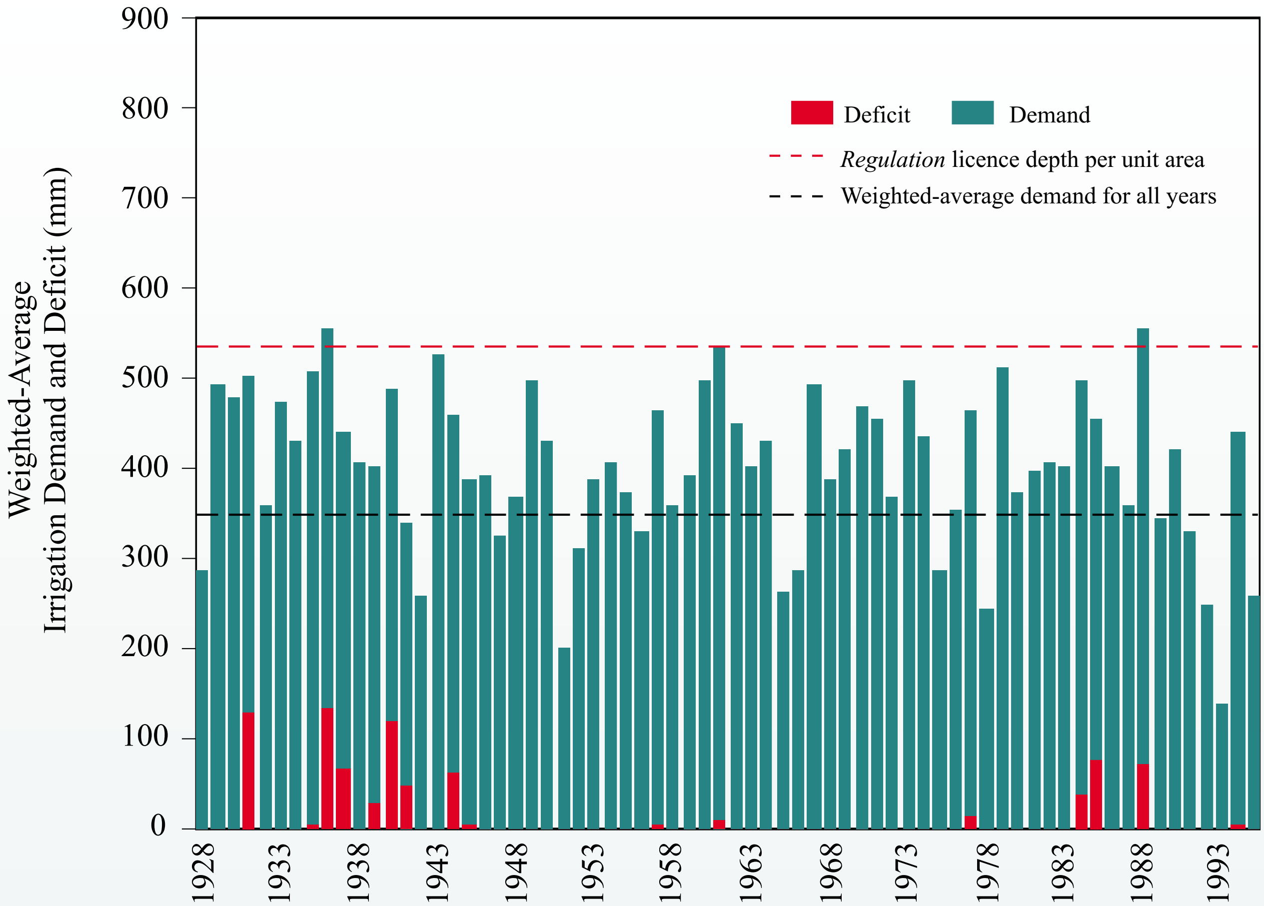
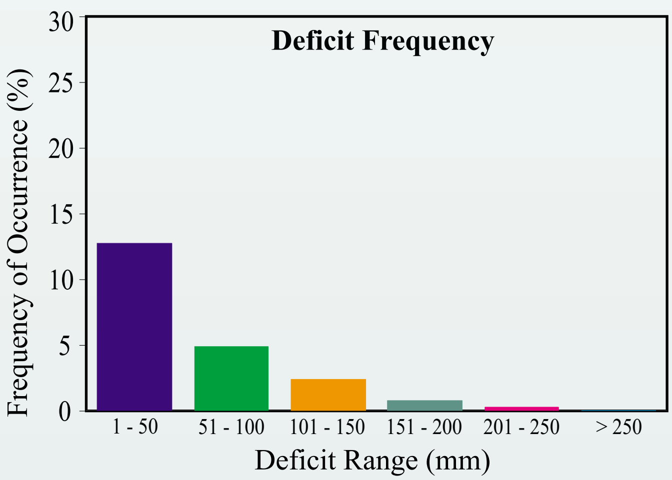


Figure A-3b. Scenario S4 irrigation deficit frequency and distribution - Bow Basin districts.



10% expansion beyond 1991 *Regulation* limit. All other variables at 1999 conditions.

Figure A-4a. Scenario S4 total demands and deficits - Oldman Basin districts.



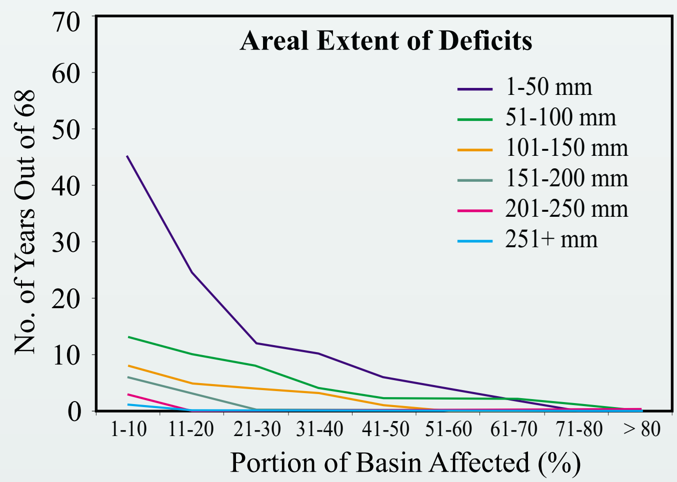
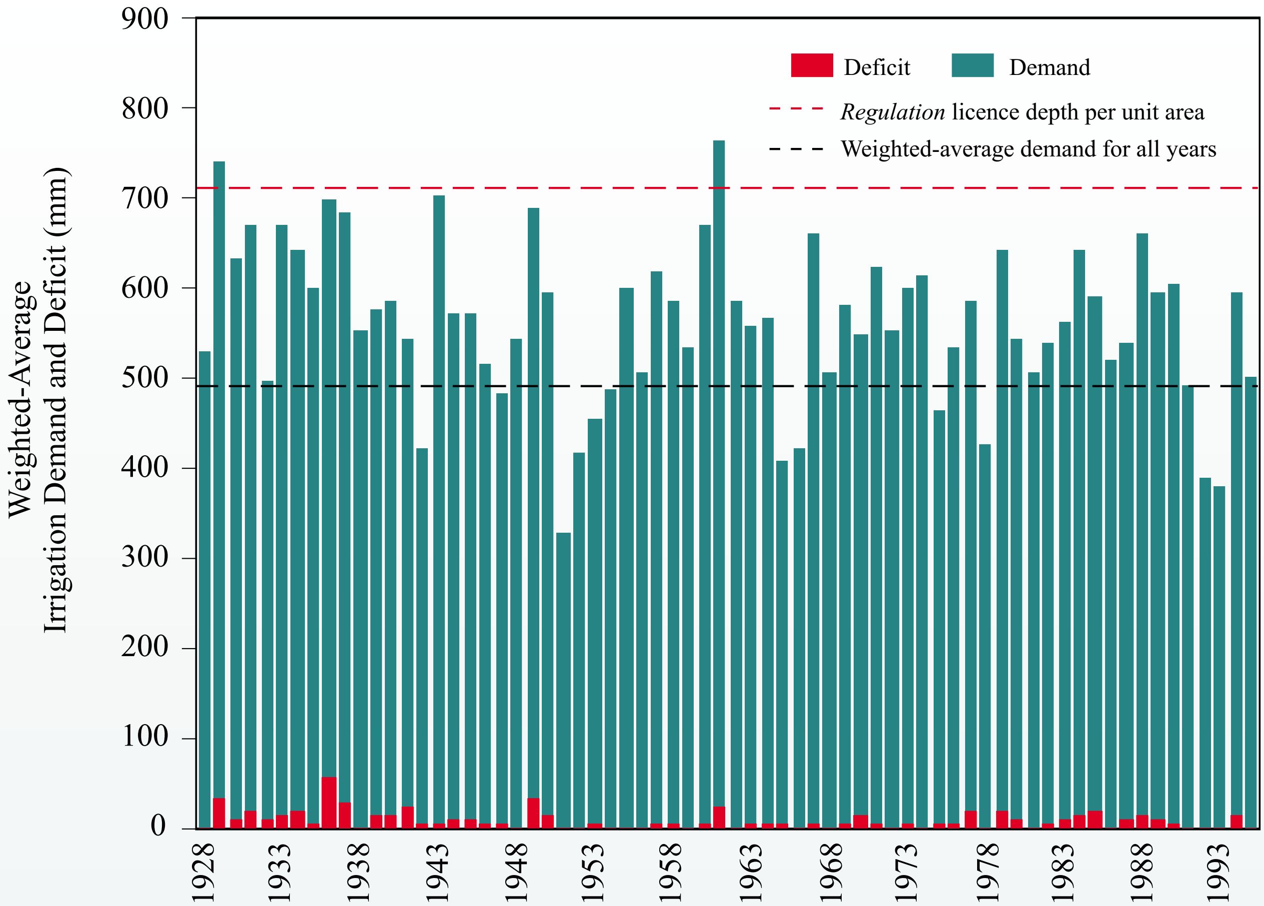
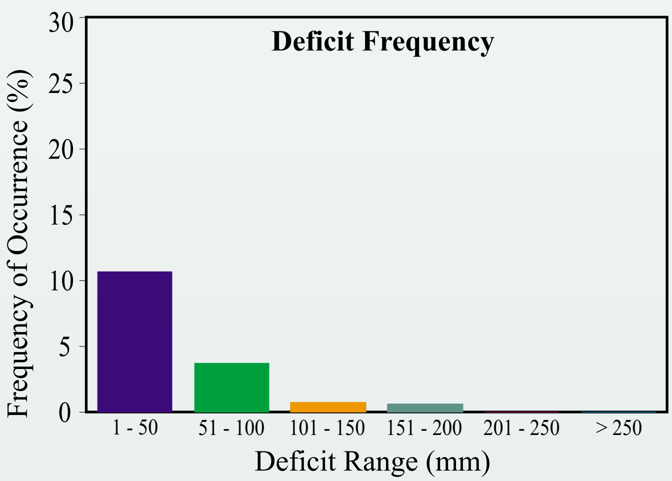


Figure A-4b. Scenario S4 irrigation deficit frequency and distribution - Oldman Basin districts.



10% expansion beyond 1991 *Regulation* limit, plus crop mix shift. All other variables at 1999 conditions.

Figure A-5a. Scenario S5 total demands and deficits - Bow Basin districts.



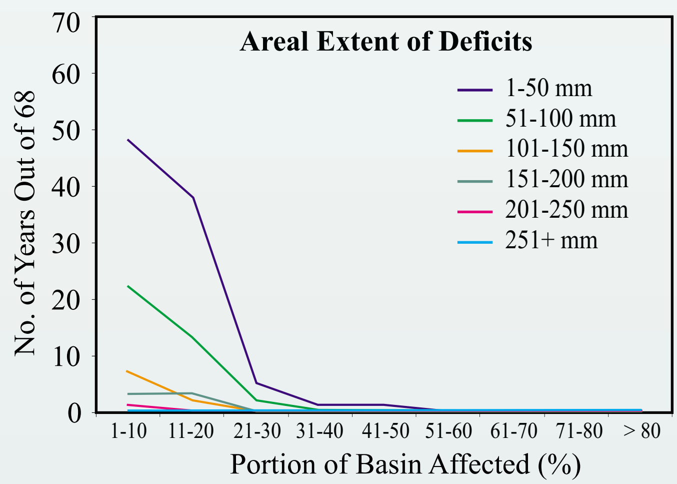
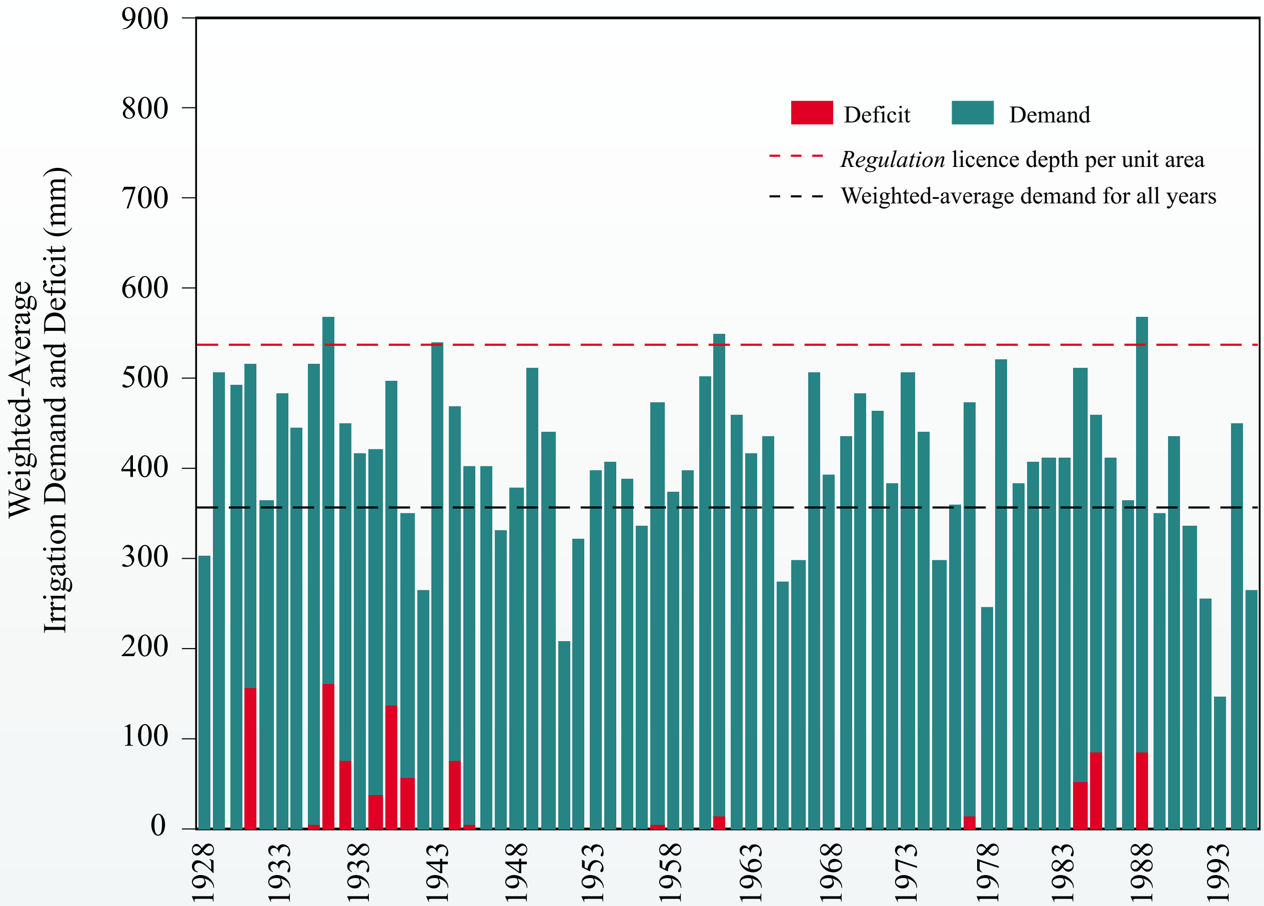


Figure A-5b. Scenario S5 irrigation deficit frequency and distribution - Bow Basin districts.



10% expansion beyond 1991 *Regulation* limit, plus crop mix shift. All other variables at 1999 conditions.

Figure A-6a. Scenario S5 total demands and deficits - Oldman Basin districts.

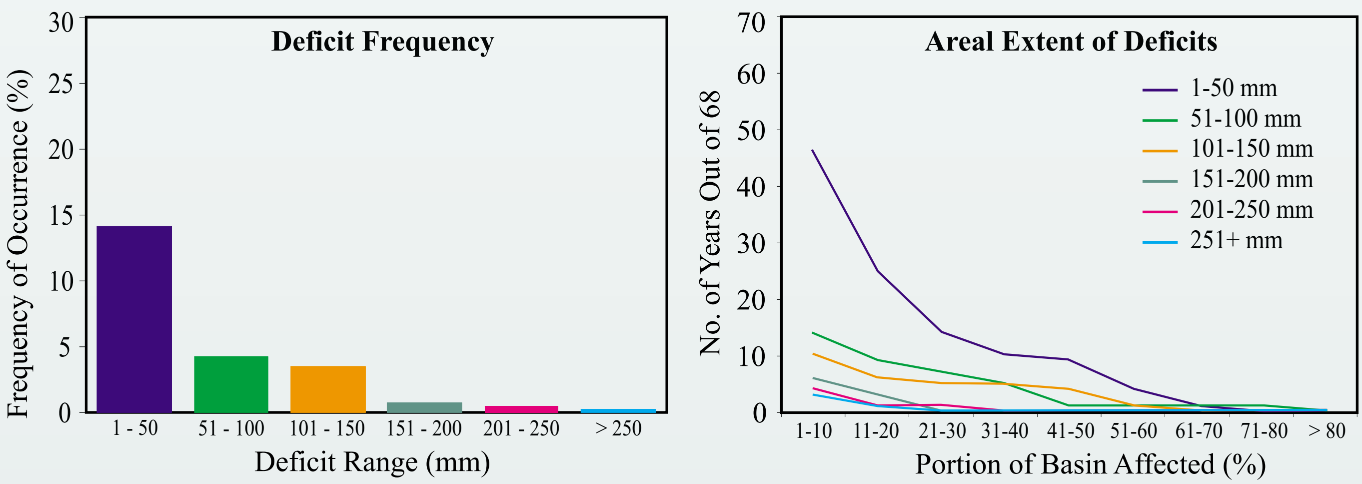
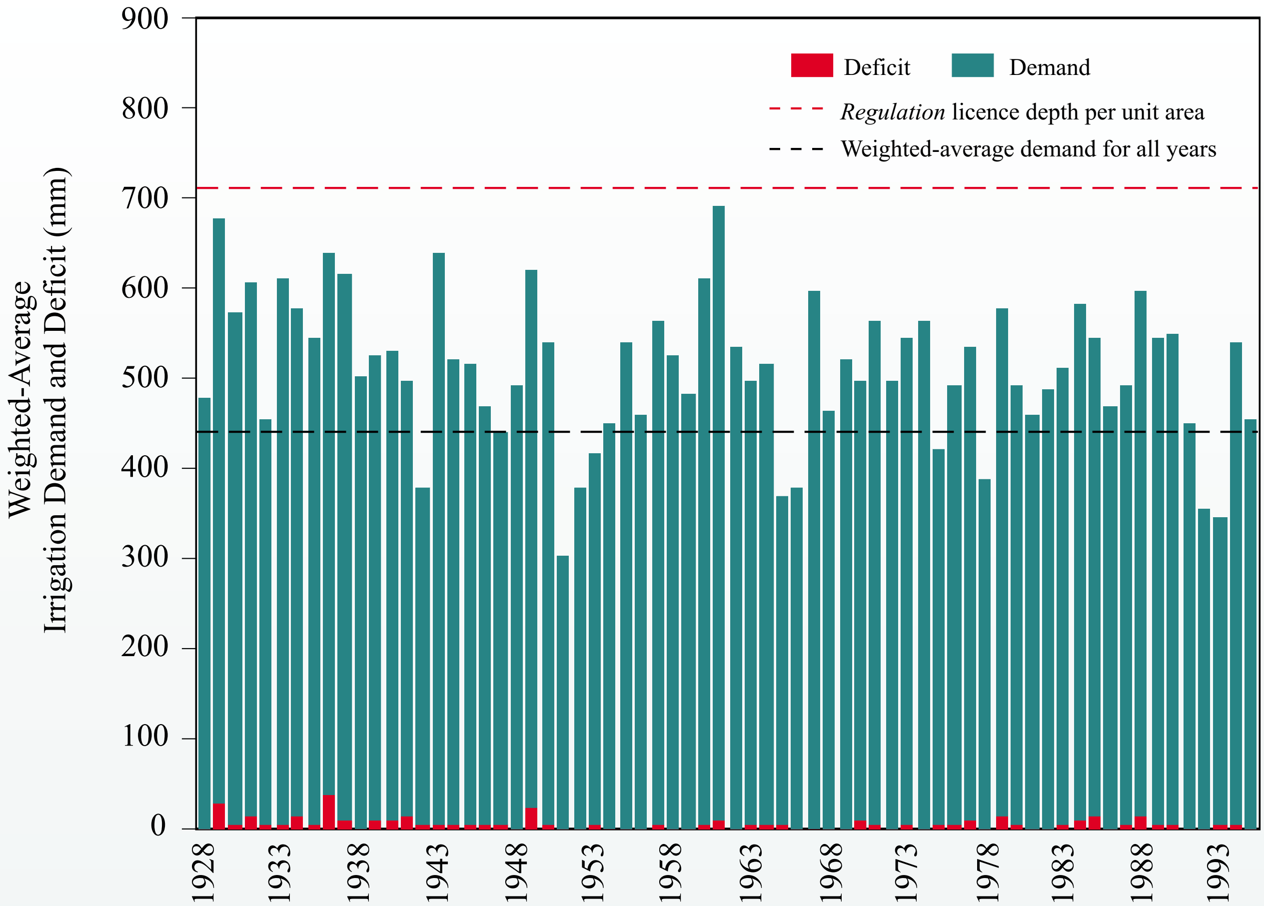
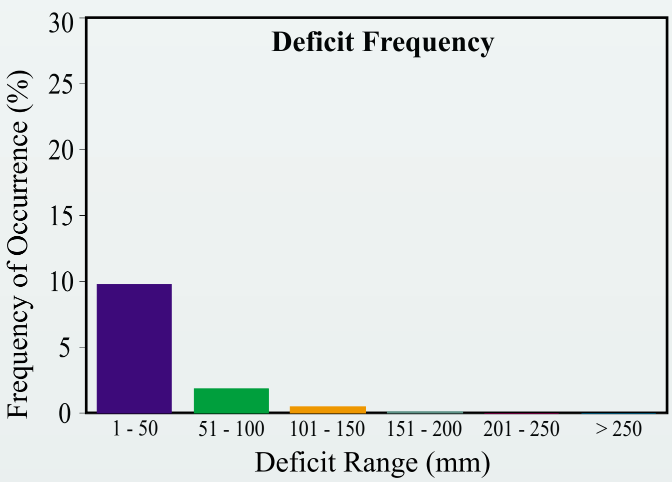


Figure A-6b. Scenario S5 irrigation deficit frequency and distribution - Oldman Basin districts.



10% expansion beyond 1991 *Regulation* limit, plus system mix shift. All other variables at 1999 conditions.

FigureA-7a. Scenario S6 total demands and deficits - Bow Basin districts.



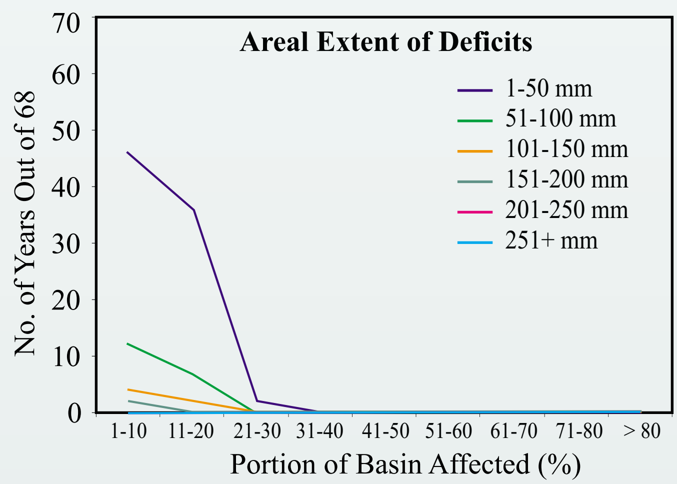


Figure A-7b. Scenario S6 irrigation deficit frequency and distribution - Bow Basin districts.

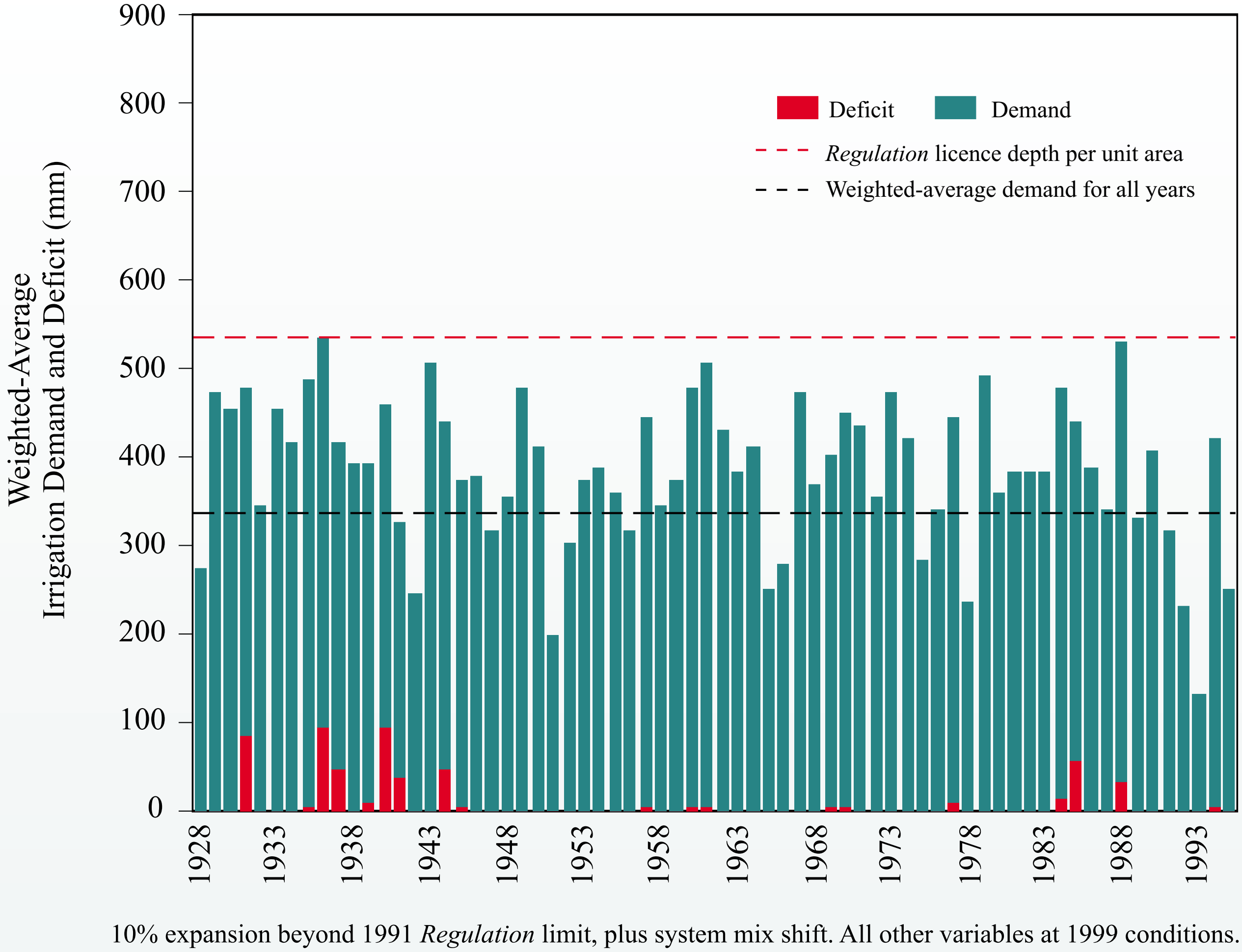


Figure A-8a. Scenario S6 total demands and deficits - Oldman Basin districts.

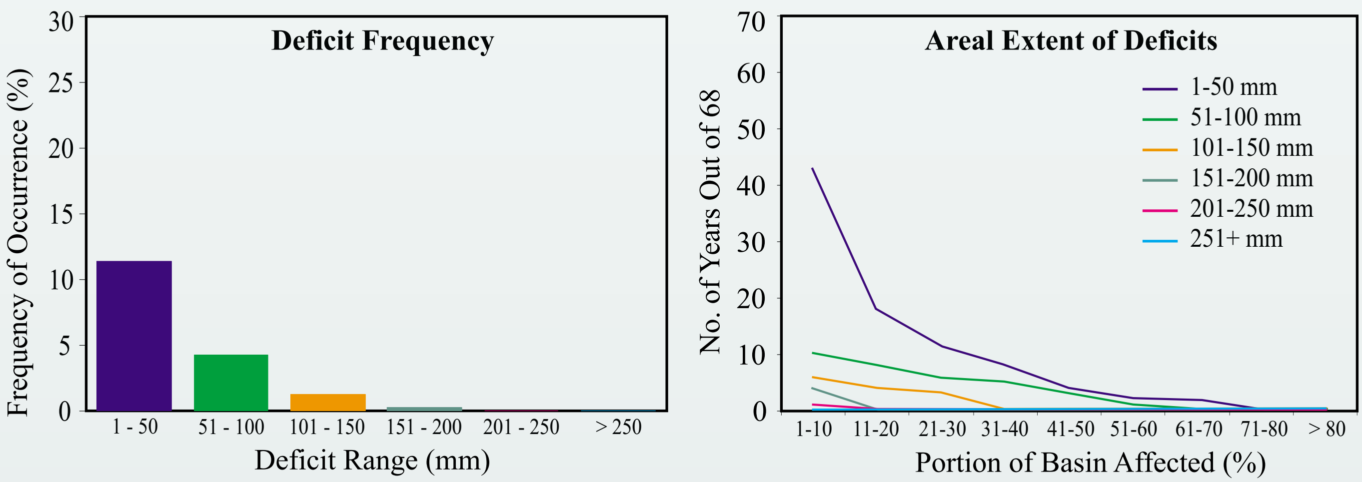
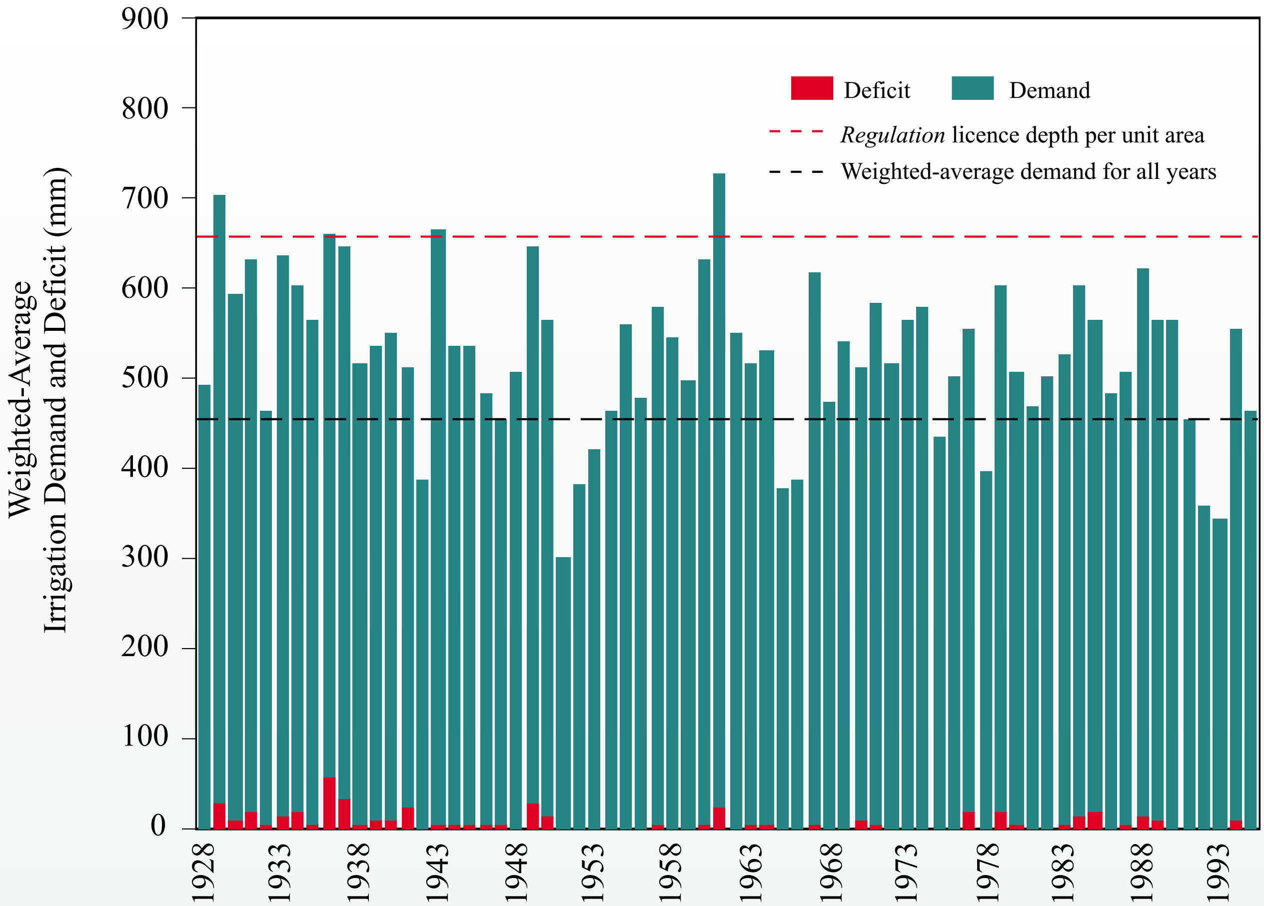
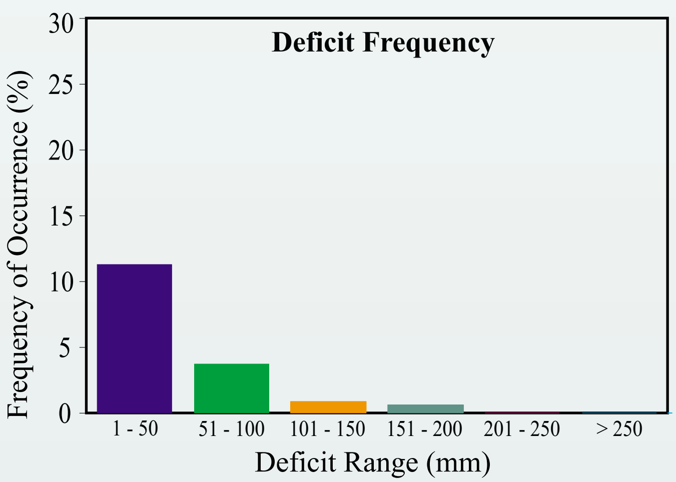


Figure A-8b. Scenario S6 irrigation deficit frequency and distribution - Oldman Basin districts.



20% expansion beyond 1991 *Regulation* limit. All other variables at 1999 conditions.

Figure A-9a. Scenario S7 total demands and deficits - Bow Basin districts.



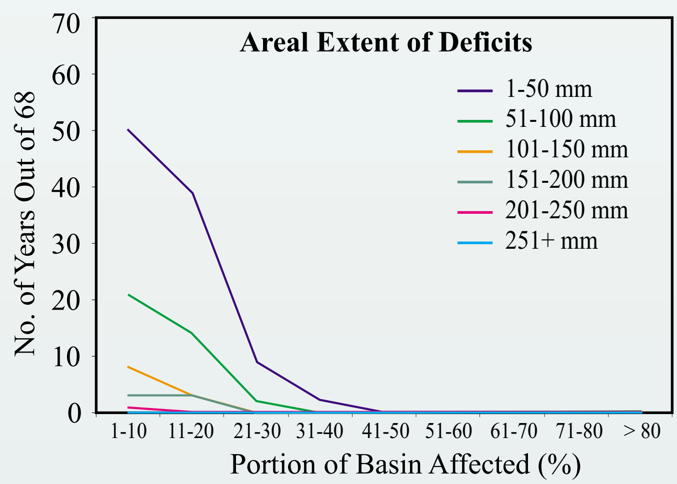
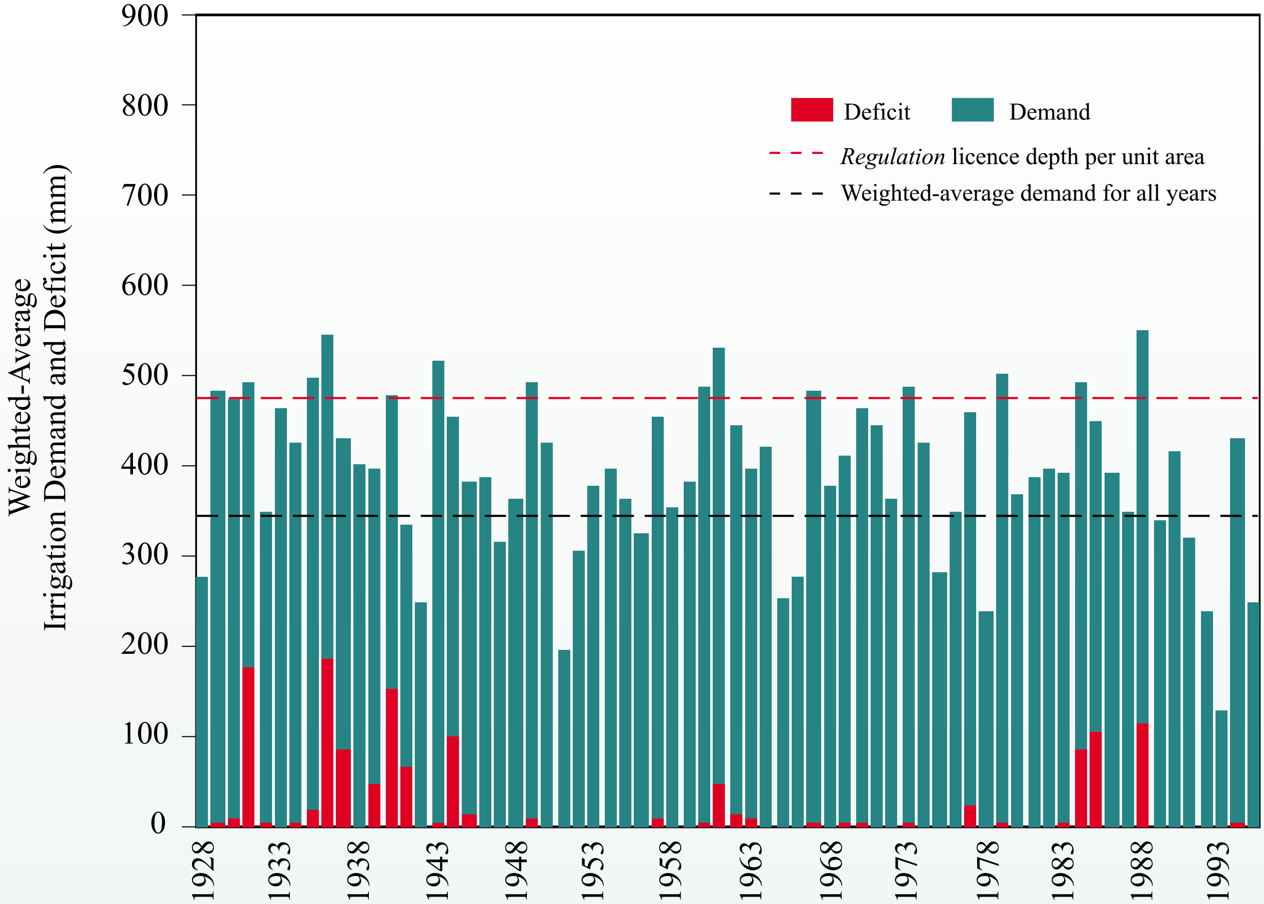
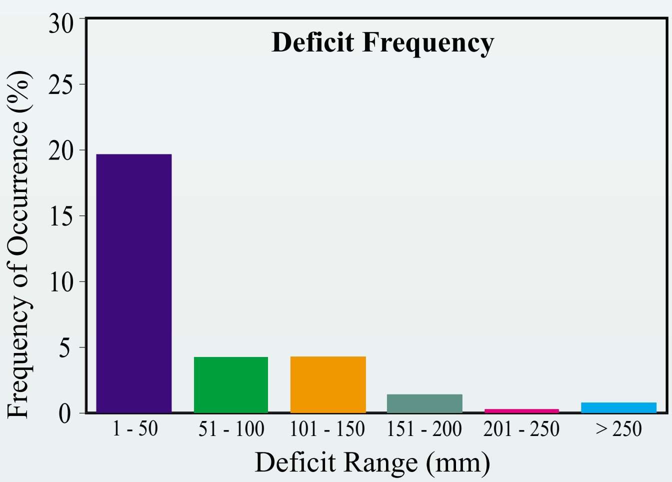


Figure A-9b. Scenario S7 irrigation deficit frequency and distribution - Bow Basin districts.



20% expansion beyond 1991 *Regulation* limit. All other variables at 1999 conditions.

Figure A-10a. Scenario S7 total demands and deficits - Oldman Basin districts.



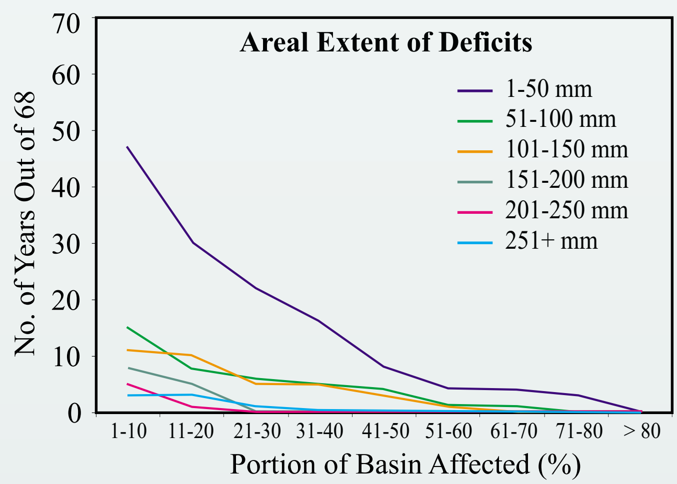
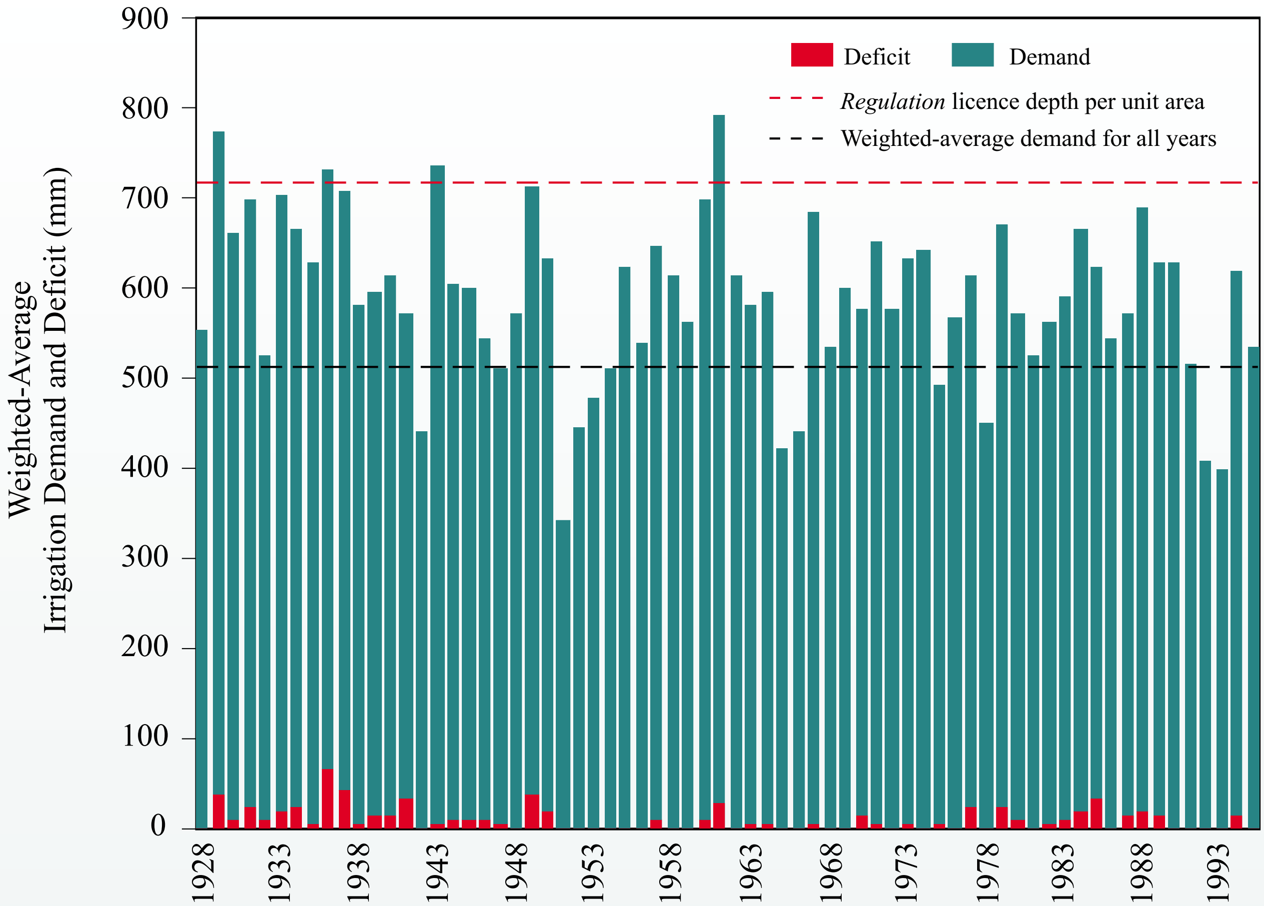


Figure A-10b. Scenario S7 irrigation deficit frequency and distribution - Oldman Basin districts.



10% expansion beyond 1991 *Regulation* limit plus near-optimum irrigation level. All other variables at 1999 conditions.

Figure A-11a. Scenario S8 total demands and deficits - Bow Basin districts.

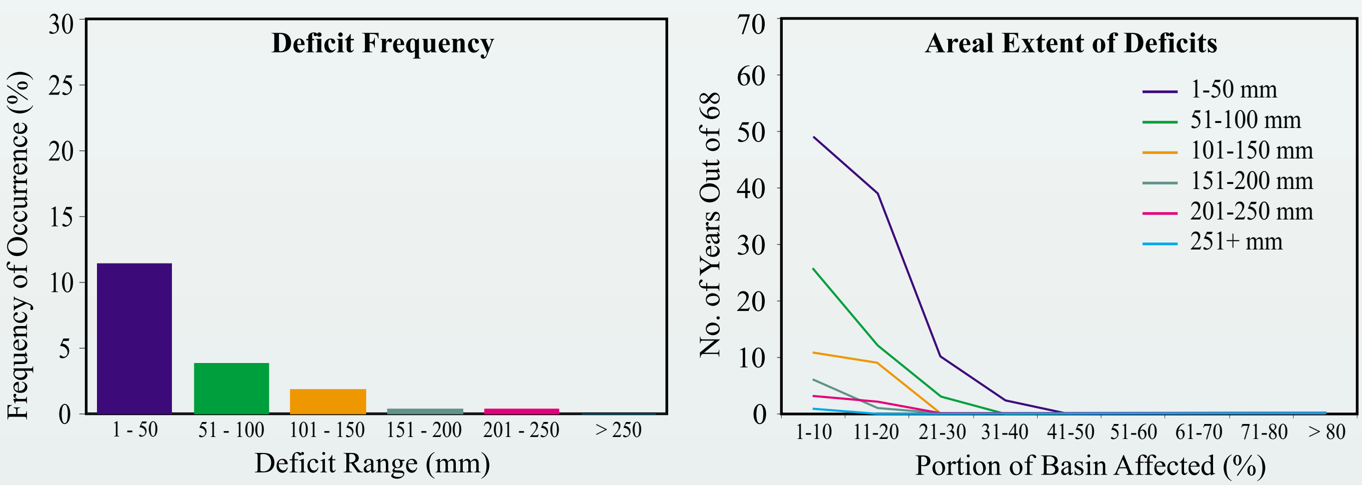
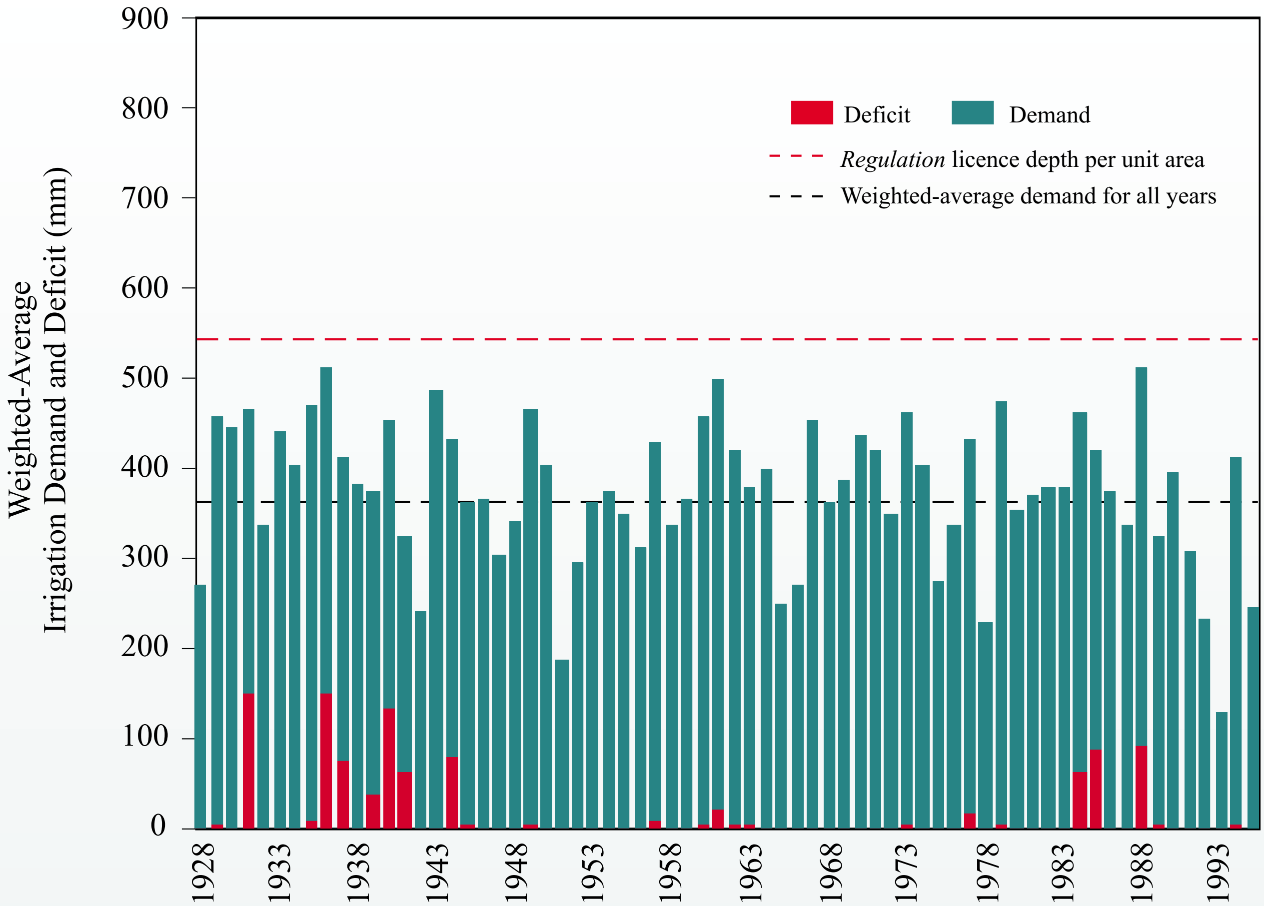
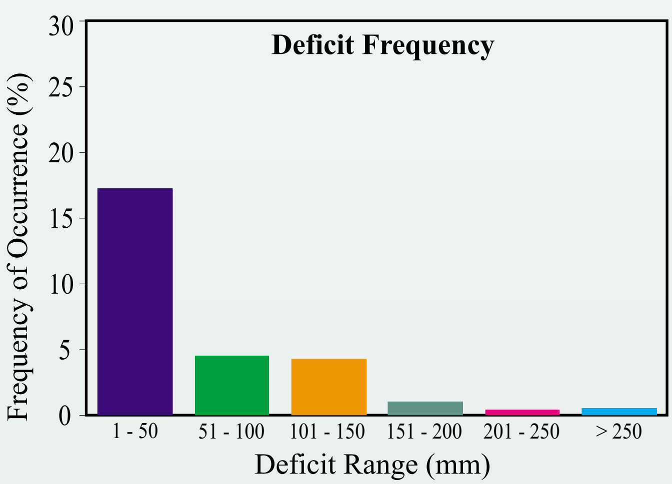


Figure A-11b. Scenario S8 irrigation deficit frequency and distribution - Bow Basin districts.



10% expansion beyond 1991 *Regulation* limit plus near-optimum irrigation level. All other variables at 1999 conditions.

Figure A-12a. Scenario S8 total demands and deficits - Oldman Basin districts.



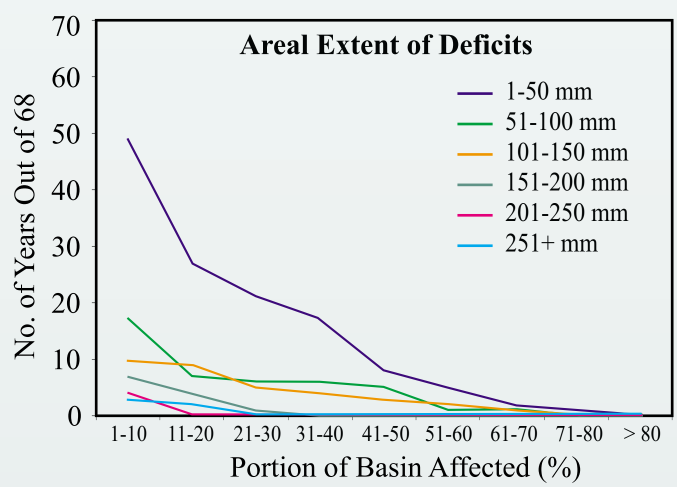


Figure A-12b. Scenario S8 irrigation deficit frequency and distribution - Oldman Basin districts.

Acronyms used in this volume

AAFC - Agriculture and Agri-Food Canada
AAFRD - Alberta Agriculture, Food and Rural Development
AENV - Alberta Environment
AID - Aetna Irrigation District
AIPA - Alberta Irrigation Projects Association
BRID - Bow River Irrigation District
EID - Eastern Irrigation District
FFIRM - Farm Financial Impact and Risk Model
GDP - Gross Domestic Product
GIS - Geographic Information System
GRIPCD - Gridded Prairie Climate Database
IDM - Irrigation District Model
LID - Leavitt Irrigation District
LNID - Lethbridge Northern Irrigation District
LRSIMM - Lethbridge Research Station Irrigation Management Model
MID - Magrath Irrigation District
MVID - Mountain View Irrigation District
NFI - Net Farm Income
PFRA - Prairie Farm Rehabilitation Administration
PPWB - Prairie Provinces Water Board
RID - Raymond Irrigation District
SMP - St. Mary Project (SMRID, RID and TID combined)
SMRID - St. Mary River Irrigation District
SSRB - South Saskatchewan River Basin
TID - Taber Irrigation District
UID - United Irrigation District
WID - Western Irrigation District
WRMM - Water Resources Management Model