APPENDIX F

SALSA Modeling Memo

SSMP Salton Sea and Individual Habitat Water Balance Modeling Memo

This document describes modeling of Salton Sea elevation and salinity under the SSMP "proposed project" scenario, 5 alternative scenarios, and one "no action" scenario, as well as the water demands from the Salton Sea and river water associated with individual projects

SALSA2 Model

SALSA2 is a Salton Sea hydrology modeled developed by CH2M Hill for IID. It is implemented in the GoldSim modeling platform, and accounts for water and salt balance under projected inflow and conservation scenarios, some parts of which can be defined by the user of the model. The model operates under a Monte Carlo framework, allowing uncertainty about model inputs to be propagated throughout all the model calculations. A detailed technical report about the development of the SALSA2 model is available on IID's website [1].

Future No Action Hydrology

The primary driver of SALSA2 model behavior is the projected future hydrology applied to the model sea. The model comes with a hydrology scenario termed "Future No Action", which "is intended to reflect recent conditions and trends plus changes which are reasonably expected to occur in the foreseeable future, based on current plans and reasonable estimates of future water uses" [2]. This hydrology encompasses "inflows from Mexico, Imperial Valley, Coachella Valley to the Salton Sea and uncertainty in Salton Sea evaporation due to climate change" [2]. The programs used to inform the Future No Action hydrology and projected changes to these inflows were [2]:

- IID Water Conservation and Transfer Project (and associated required mitigation measures)
- Coachella Canal Lining Project
- All-American Canal Lining Project
- Colorado River Basin Salinity Control Program
- Coachella Valley Water District Water Management Plan
- Mexicali Wastewater Improvements
- Mexicali Power Production
- Total Maximum Daily Loads Implementation.

This hydrology scenario was also designed while considering [2]:

- Level of desalination to be implemented in CVWD WMP
- Future reductions in Mexico flows in the New River
- Future reductions of drainwater flows in IID or reuse of drainwater within IID
- Increased consumption in the Imperial Valley associated with nutrient and/or selenium treatment
- Climate change effects on Salton Sea evaporation.

Section 4 of [2] goes into more detail about the specific factors considered for each of these conditions in the development of the Future No Action Hydrology. In the SALSA2 model, there are two variants of

the Future No Action available for selection in the model interface. There is a "moderate uncertainty" inflow scenario that matches the graphics featured in [2] (with some minor differences likely attributable to changes to the model since the hydrology report was published in 2018) and a "low uncertainty" variant with less variability in the probability distributions (resulting in higher flows on average) used to model these flows in Goldsim's Monte Carlo framework. The mean value of the inflow variables through water year 2046 from the moderate uncertainty scenario have been copied from the model into Table 1.

SSMP Scenario Implementation in SALSA2

SALSA2 does not allow for adding arbitrary increases, reductions, or diversions of inflowing water into the sea for use in conservation projects. However, it does allow for a user-specified annual construction schedule of shallow water habitat area that uses water at a rate of 6-af/yr per acre of habitat constructed. Therefore, it's possible to emulate the use of water usage of other project alternatives by having the model simulate an amount of habitat area that would use an equivalent amount of water. We converted the estimated water use for project alternatives into an equivalent habitat area based on the following annual water uses per acre:

- Desert Shores Channel Restoration (6 af/acre)
- Future Dust Suppression (1 af/acre)
- Alamo River Project (6 af/acre)
- North Lake Project (6 af/acre)
- North Lake Demonstration (6 af/acre)
- New River Expansion Project (6 af/acre)
- Bombay Beach Wetland (6 af/acre)
- Alternative 1 ponds (6 af/acre)
- Alternative 2 wetlands (5 af/acre)
- Alternative 3 ponds (6 af/acre)
- Alternative 4 enhancing wetlands (6 af/acre).

The acreages of these project alternatives are shown in Table 2. Construction of all project alternatives is gradual, with 10% of the acreage coming online in 2023, an additional 20% in each year from 2024-2027, and the final 10% in 2028. After 2028, the water use (and equivalent habitat area) associated with project alternatives is constant.

Individual Project Water Demand Estimation

Besides the Salton Sea as a whole, we also estimate the Sea water and river water demands associated with individual projects that constitute different SSMP alternatives. These water demands address evaporative loss, seepage loss and outflows from individual projects. Most aquatic habitat projects, with the exception of wetlands formed at river mouths, assume the use of river water and higher salinity Salton Sea water use to achieve mid-salinity conditions within habitats.

The concept of "residence time" is important for the water quality of managed habitat areas. Insufficient water exchange, i.e. water with too long a residence time, can lead to poor water quality. The SALSA model does not impose residence time restrictions in its modeling of aquatic habitat; therefore, an independent modeling exercise was undertaken to water demand in 3 types of

management projects: (1) aquatic habitat pond areas, (2) the New River Expansion project, which receives the outflow from SCH areas, and (3) wetland areas.

The water demand was estimated using mass balance for water volumes and dissolved salt under applied time series of monthly precipitation, evaporation, and seepage from 2018-2028. In certain types of projects, additional constraints in the form of target salinities and maximum residence times affect the estimated water demands.

The following modeling assumptions were used:

- Habitat ponds have an average depth 4ft
- The New River Expansion Project and wetland areas have an average depth of 3ft
- Annually, there is 6ft of evaporation, 2ft of seepage, and 3 inches of rain
- Seepage is applied uniformly over the year, evaporation is divided according to the monthly pattern in the DWR supply memo, and precipitation is divided according to historical averages from the Westmoreland station from CIMIS, as was done in the DWR supply memo
- River water salinity is a constant value of 3ppt; sea water salinity varies annually taken from the above SALSA modeling of the proposed project scenario using low uncertainty inflows, ranging from ~64ppt in 2018 to ~122ppt in 2028
- Evaporation and precipitation change water volumes without affecting salt mass; seepage withdraws water according to the current timestep's salinity

All 3 types of projects need to meet losses due to evaporation and seepage, but the handling of maximum residence time and target salinity varies slightly by project type:

1. Habitat ponds have a target salinity of 30 ppt, and the balance of river and sea water required to meet that target at the end of the timestep is calculated at each timestep. Additional evaporation and seepage demands equal to 5% of the project area are added to accommodate the necessary mixing ponds to achieve this. Habitat ponds' residence time is their total storage volume divided by the inflow rate; if this quantity would be above 90 days, additional water demand is added and outflow is released to maintain a fixed volume.
2. The New River Expansion Project always receives the above outflow from SCH areas as a fixed input. It also has the same 90-day maximum residence time requirement which can trigger additional demands, but it has no fixed target salinity and always takes river water for its demands.
3. Wetland areas have neither residence time nor target salinity requirements and simply take river water equal to the losses due to evaporation and seepage.

Results

Figure 1 shows the total sea inflow under the low- and moderate-uncertainty variants of the Future No Action hydrology. Note that the reduced uncertainty in future flows results in higher modeled flows on average. Figure 2 shows SALSA2's estimated sea elevations under the water use of the SSMP scenarios

as implemented per the above description, and Figure 3 shows the corresponding modeled sea salinities.

Table 3 shows the water demand per unit area for river water in 2028 according to the estimates from the water use modeling. It only depends on common assumptions used in the modeling (average depth, boundary conditions, etc.) but not the aerial footprint. Similarly, Table 4 shows the Salton Sea water demand in 2028 per unit area. Table 5 and Table 6 show the corresponding total volumes, so these do vary with the size of the proposed project areas.

References

[1] CH2M Hill, 2018. Salton Sea Hydrological Modeling and Results. Tech. report. https://www.iid.com/home/showpublisheddocument/17299/636763993652100000

[2] CH2M Hill, 2018. Salton Sea Hydrology Development. Tech. report. https://www.iid.com/home/showpublisheddocument/17297/636763993646630000

Table 1. SALSA2 v3.27 "Future No Action" inflows, moderate uncertainty, mean value in AF.

Year	Inflows_ NewR_ Mexico:	Inflows_A lamoR_ Mexico:	Inflows_ DirectDra ins_West:	Inflows_ NewR_ IID:	Inflows_ DirFlows_ bet_Alam o_New:	Inflows_A lamoR_ IID:	Inflows_ DirectDra ins_East:	Inflows_ GW_IID:	Inflows_ Whitewat er_ CVWD:	Inflows_ DirectDra ins_ CVWD:	Inflows_L ocalw_Salt Creek:	Inflows_L ocalw_ EAST:	Inflows_L ocalw_W estside_ GW:	Inflows_L ocalw_ WEST:	Inflows_L ocalw_Sa nFelipe:	Inflows_ NewR:	Inflows_A lamoR:	Inflows_ DirectDra ins:	Inflows_S SRREI:	Inflows_S SWIFT:	Inflows_ Mexico:	Inflows_ IID:	Inflows_ CVWD:	Inflows_L ocalwater shed:	Inflows_ Total:
2018	89778	2000	21168	215392	37359	450837	17974	1000	31150	21238	1359	503.5	10000	1996	5352	305170	452837	97739	886896	343030	91778	743730	52387	19211	907107
2019	84006	2000	20161	205151	35583	429403	17120	1000	31595	21542	1254	431.8	10000	1883	5047	289157	431403	94406	846560	327053	86006	708418	53137	18616	866176
2020	77950	2000	19113	194485	33733	407077	16229	1000	32135	21910	1287	454	10000	1890	5068	272435	409077	90986	804633	310925	79950	671638	54045	18699	824332
2021	69893	2000	18580	189058	32792	395718	15777	1000	32760	22336	1278	447.9	10000	1922	5154	258951	397718	89484	778913	298143	71893	652923	55096	18802	798715
2022	63683	2000	18464	187878	32587	393249	15678	1000	33504	22843	1272	443.7	10000	1866	5004	251561	395249	89572	769885	291340	65683	648856	56347	18586	789471
2023	57293	2000	18383	187053	32444	391521	15609	1000	34409	23460	1295	460	10000	1936	5190	244346	393521	89896	762172	285240	59293	646010	57870	18881	782053
2024	50423	2000	18224	185439	32164	388142	15475	1000	35559	24245	1280	449.6	10000	1905	5107	235862	390142	90107	751671	277809	52423	640444	59804	18742	771413
2025	43858	2000	18061	183778	31876	384666	15336	1000	36833	25113	1305	466.4	10000	1947	5219	227636	386666	90386	741520	270993	45858	634716	61946	18937	761457
2026	37397	2000	17855	181684	31513	380283	15161	1000	38309	26119	1312	471	10000	1946	5218	219081	382283	90648	730321	263919	39397	627497	64428	18947	750268
2027	36613	2000	17469	177758	30832	372066	14834	1000	39657	27039	1338	489.1	10000	1936	5190	214371	374066	90173	718268	260557	38613	613959	66696	18953	738221
2028	37189	2000	17089	173887	30160	363963	14511	1000	40744	27780	1320	477.1	10000	1953	5237	211076	365963	89539	707323	258377	39189	600610	68524	18987	727311
2029	37777	2000	16738	170315	29541	356487	14212	1000	41537	28320	1291	456.8	10000	1919	5145	208092	358487	88811	696927	256065	39777	588293	69858	18812	716739
2030	36920	2000	16379	166668	28908	348854	13908	1000	42075	28687	1350	497.4	10000	1986	5325	203589	350854	87883	684401	252340	38920	575719	70762	19160	704561
2031	35831	2000	16074	163564	28370	342357	13649	1000	42385	28898	1330	483.3	10000	2000	5361	199395	344357	86992	673128	248470	37831	565014	71283	19173	693301
2032	37072	2000	15692	159671	27695	334207	13324	1000	42519	28989	1392	525.8	10000	2261	6062	196743	336207	85700	661169	246716	39072	551588	71508	20241	682410
2033	36607	2000	15340	156094	27074	326721	13026	1000	42498	28975	1469	578.5	10000	2528	6776	192701	328721	84415	648335	243444	38607	539256	71473	21351	670686

Year	Inflows_ NewR_ Mexico:	Inflows_A lamoR_ Mexico:	Inflows_ DirectDra ins_West:	Inflows_ NewR_ IID:	Inflows_ DirFlows_ bet_Alam o_New:	Inflows_A lamoR_ IID:	Inflows_ DirectDra ins_East:	Inflows_ GW_IID:	Inflows_ Whitewat er_ CVWD:	Inflows_ DirectDra ins_ CVWD:	Inflows_L ocalw_Sal tCreek:	Inflows_L ocalw_ EAST:	Inflows_L ocalw_W estside_ GW:	Inflows_L ocalw_ WEST:	Inflows_L ocalw_Sa nFelipe:	Inflows_ NewR:	Inflows_A lamoR:	Inflows_ DirectDra ins:	Inflows_S SRREI:	Inflows_S SWIFT:	Inflows_ Mexico:	Inflows_ IID:	Inflows_ CVWD:	Inflows_L ocalwater shed:	Inflows_ Total:
2034	36720	2000	14956	152180	26395	318528	12699	1000	42416	28920	1439	558	10000	2460	6594	188900	320528	82970	634814	239349	38720	525758	71336	21051	656865
2035	35353	2000	14619	148753	25801	311356	12413	1000	42290	28834	1534	623.2	10000	2657	7124	184107	313356	81667	621419	235055	37353	513942	71124	21939	644358
2036	33360	2000	14599	148553	25766	310937	12397	1000	43359	29562	1475	582.7	10000	2517	6747	181913	312937	82324	620533	233493	35360	513252	72921	21321	642854
2037	33059	2000	14650	149070	25856	312020	12440	1000	44248	30169	1537	625.5	10000	2667	7150	182130	314020	83114	623512	235065	35059	515036	74417	21980	646491
2038	34635	2000	14679	149369	25908	312644	12465	1000	45028	30700	1485	589.5	10000	2556	6853	184003	314644	83752	627427	237369	36635	516065	75728	21484	649911
2039	35455	2000	14614	148708	25793	311260	12409	1000	45812	31235	1495	596.7	10000	2530	6782	184163	313260	84052	627287	238252	37455	513785	77047	21404	649690
2040	34850	2000	14616	148719	25795	311285	12410	1000	46611	31780	1529	619.4	10000	2654	7115	183570	313285	84601	628067	238825	36850	513825	78391	21917	650984
2041	36290	2000	14620	148768	25804	311387	12414	1000	47465	32362	1476	583.4	10000	2554	6848	185058	313387	85200	631111	240847	38290	513993	79827	21462	653572
2042	36443	2000	14664	149208	25880	312308	12451	1000	48240	32890	1521	614.4	10000	2641	7081	185651	314308	85885	634084	242493	38443	515511	81130	21858	656942
2043	36653	2000	14687	149447	25921	312809	12471	1000	48939	33367	1459	571.9	10000	2545	6822	186100	314809	86446	636295	243320	38653	516336	82306	21398	658692
2044	37556	2000	14732	149906	26001	313769	12509	1000	49564	33793	1518	611.9	10000	2606	6986	187463	315769	87035	639831	245530	39556	517918	83357	21722	662552
2045	37541	2000	14733	149915	26003	313788	12510	1000	50139	34185	1466	576.9	10000	2485	6661	187456	315788	87430	640812	245722	39541	517949	84323	21189	663002
2046	37535	2000	14770	150296	26069	314584	12542	1000	50668	34546	1504	602.5	10000	2575	6903	187830	316584	87927	643010	246905	39535	519261	85214	21584	665593

Table 2. Estimated water use of SSMP project alternatives (in acres). All alternatives (including 'No Action') also model completion of the SCH Project in 2023 (3,770 acres)

SSMP Project Areas	Type	Proposed Project	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	No Action
Desert Shores Channel Restoration	pond	30	0	0	0	0	30	0
Dust Suppression	dust control	14,900	0	0	0	14,900	23,973	0
Alamo River Project	pond	7,257	3,558	4,500	5,855	0	10,216	0
North Lake Project	pond	3,862	3,862	5,363	3,862	0	3,862	0
North Lake Demonstration	pond	160	160	160	160	0	160	0
New River Expansion Project	pond	6,850	5,384	4,548	9,411	0	9,563	0
Bombay Beach Wetland	wetland	903	903	993	0	0	903	0
Alternative 1	pond	0	11,823	0	0	0	0	0
Alternative 2	wetland	0	0	10,126	0	0	0	0
Alternative 3	pond	0	0	0	6,402	0	0	0
Alternative 4	enhancing wetlands	0	0	0	0	10,790	0	0
TOTAL		33,962	25,690	25,690	25,690	25,690	48,707	0

Table 3. Estimated per-area river water use of SSMP project alternatives (in ft., i.e. volume of water demand in ac.-ft. per ac. of project area). All alternatives (including 'No Action') also model completion of the SCH Project in 2023 (14.36 ft., annually)

SSMP Project Areas	Type	Proposed Project	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	No Action
Desert Shores Channel Restoration*	pond	0	0	0	0	0	0	0
Dust Suppression*	dust control	0	0	0	0	0	0	0
Alamo River Project	pond	14.36	14.36	14.36	14.36	0	14.36	0
North Lake Project	pond	14.36	14.36	14.36	14.36	0	14.36	0
North Lake Demonstration	pond	14.36	14.36	14.36	14.36	0	14.36	0
New River Expansion Project	pond	12.17	12.17	12.17	12.17	0	12.17	0
Bombay Beach Wetland	wetland	7.75	7.75	7.75	0	0	7.75	0
Alternative 1	pond	0	14.36	0	0	0	0	0
Alternative 2	wetland	0	0	7.75	0	0	0	0
Alternative 3	pond	0	0	0	14.36	0	0	0
Alternative 4	enhancing wetlands	0	0	0	0	7.75	0	0

*Assumes use of groundwater or water sources besides Salton Sea or its inflowing rivers

Table 4. Estimated per-area Salton Sea water use of SSMP project alternatives (in ft., i.e. volume of water demand in ac.-ft. per ac. of project area). All alternatives (including 'No Action') also model completion of the SCH Project in 2023 (2.25 ft., annually)

SSMP Project Areas	Type	Proposed Project	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	No Action
Desert Shores Channel Restoration*	pond	0	0	0	0	0	0	0
Dust Suppression*	dust control	0	0	0	0	0	0	0
Alamo River Project	pond	2.25	2.25	2.25	2.25	0	2.25	0
North Lake Project	pond	2.25	2.25	2.25	2.25	0	2.25	0
North Lake Demonstration	pond	2.25	2.25	2.25	2.25	0	2.25	0
New River Expansion Project	pond	0.00	0.00	0.00	0.00	0	0.00	0
Bombay Beach Wetland	wetland	0.00	0.00	0.00	0	0	0.00	0
Alternative 1	pond	0	2.25	0	0	0	0	0
Alternative 2	wetland	0	0	0.00	0	0	0	0
Alternative 3	pond	0	0	0	2.25	0	0	0
Alternative 4	enhancing wetlands	0	0	0	0	0.00	0	0

*Assumes use of groundwater or water sources besides Salton Sea or its inflowing rivers

Table 5. Estimated river water use of SSMP project alternatives (in ac.-ft.). All alternatives (including 'No Action') also model completion of the SCH Project in 2023 (54,128 ac.-ft., annually)

SSMP Project Areas	Type	Proposed Project	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	No Action
Desert Shores Channel Restoration	pond	0	0	0	0	0	0	0
Dust Suppression	dust control	0	0	0	0	0	0	0
Alamo River Project	pond	104,193	51,084	64,609	84,064	0	146,678	0
North Lake Project	pond	55,449	55,449	77,000	55,449	0	55,449	0
North Lake Demonstration	pond	2,297	2,297	2,297	2,297	0	2,297	0
New River Expansion Project	pond	83,342	65,505	55,334	114,500	0	116,350	0
Bombay Beach Wetland	wetland	6,998	6,998	7,696	0	0	6,998	0
Alternative 1	pond	0	169,750	0	0	0	0	0
Alternative 2	wetland	0	0	78,477	0	0	0	0
Alternative 3	pond	0	0	0	91,918	0	0	0
Alternative 4	enhancing wetlands	0	0	0	0	83,623	0	0

*Assumes use of groundwater or water sources besides Salton Sea or its inflowing rivers

Table 6. Estimated annual Salton Sea water use of SSMP project alternatives (in ac.-ft.). All alternatives (including 'No Action') also model completion of the SCH Project in 2023 (8,490 ac.-ft., annually)

SSMP Project Areas	Type	Proposed Project	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	No Action
Desert Shores Channel Restoration	pond	0	0	0	0	0	0	0
Dust Suppression	dust control	0	0	0	0	0	0	0
Alamo River Project	pond	16,343	8,013	10,134	13,186	0	23,007	0
North Lake Project	pond	8,698	8,698	12,078	8,698	0	8,698	0
North Lake Demonstration	pond	360	360	360	360	0	360	0
New River Expansion Project	pond	0	0	0	0	0	0	0
Bombay Beach Wetland	wetland	0	0	0	0	0	0	0
Alternative 1	pond	0	26,626	0	0	0	0	0
Alternative 2	wetland	0	0	0	0	0	0	0
Alternative 3	pond	0	0	0	14,418	0	0	0
Alternative 4	enhancing wetlands	0	0	0	0	0	0	0

*Assumes use of groundwater or water sources besides Salton Sea or its inflowing rivers

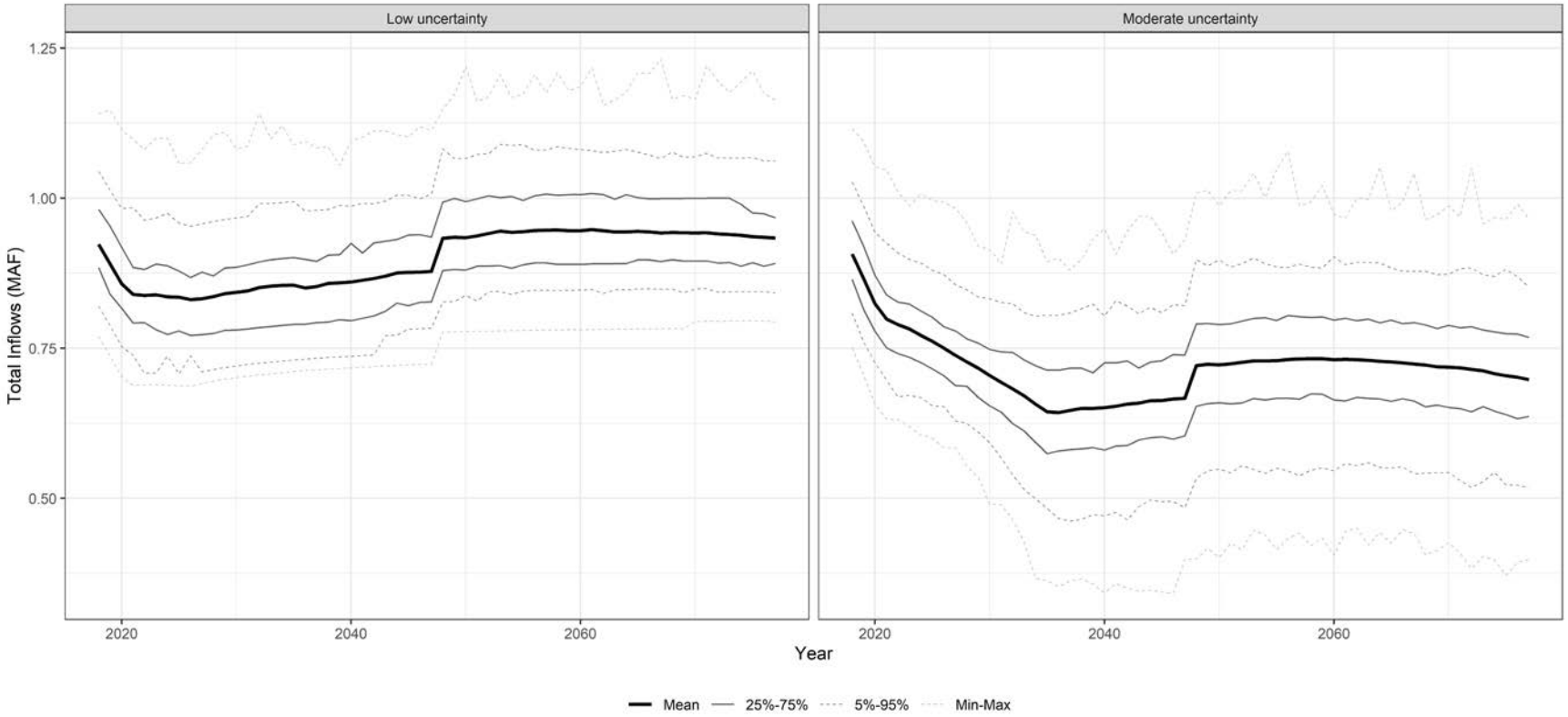

Figure 1. Total sea SALSA2 inflows under the low uncertainty and moderate uncertainty variants of the "Future No Action" hydrology.

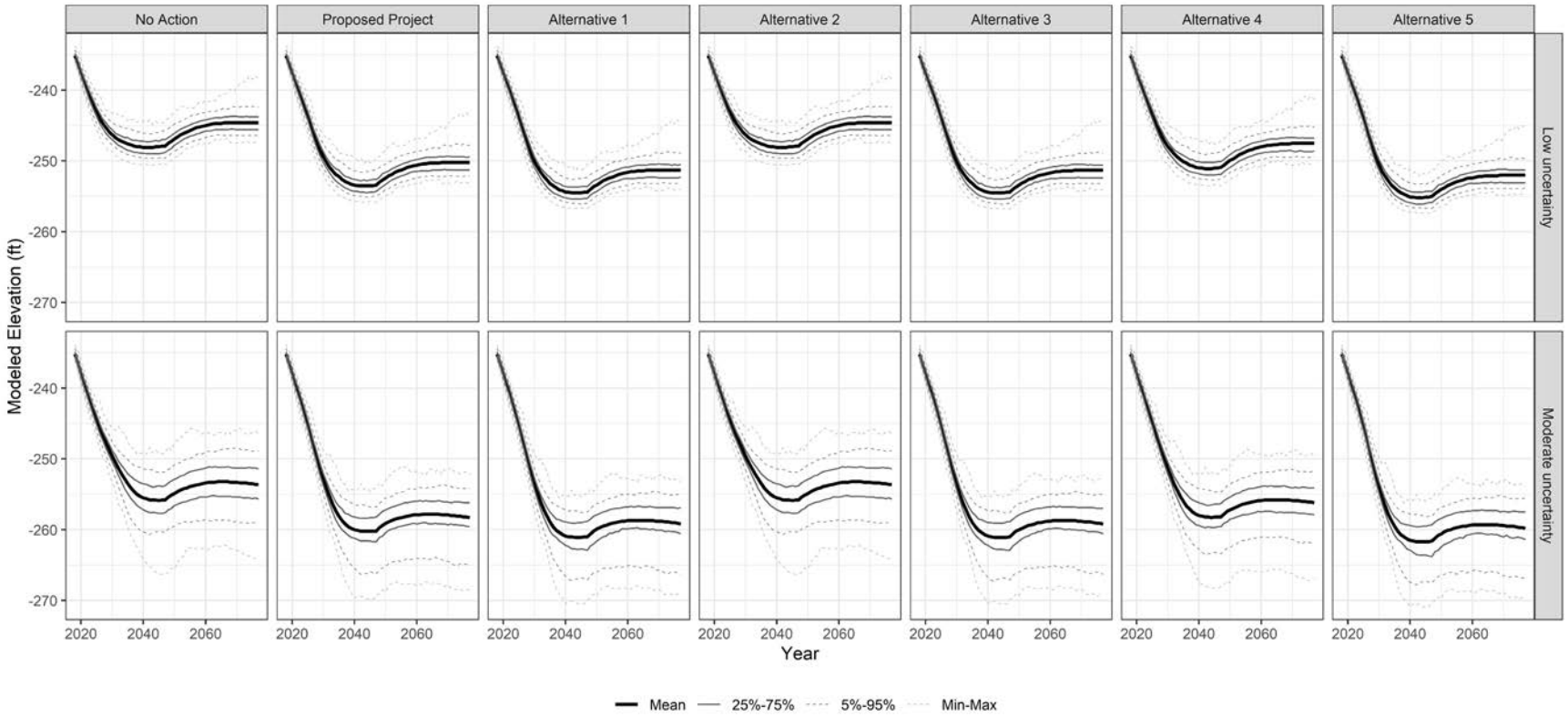

Figure 2. SALSA2 modeled sea elevations under SSMP project alternatives.

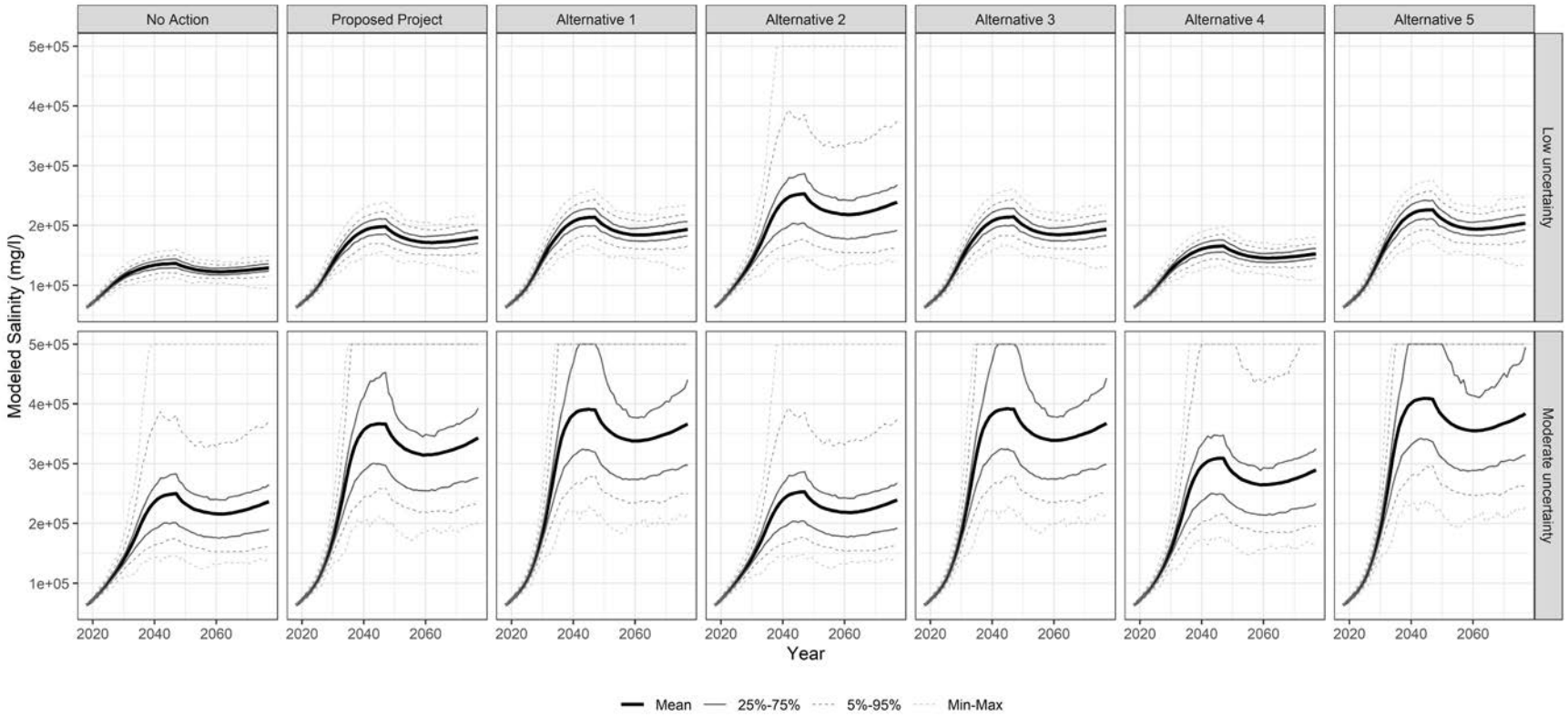

Figure 3. SALSA2 modeled sea salinity under SSMP project alternatives.