APPENDIX I: Water Budget

1.1 Proposed Project

Ecosystem restoration measures proposed for the Bosque Wetlands Park (Park) include the modification of existing wetlands, construction of new wetlands, construction of new wet marshes, enhancement of riparian habitat, and construction of new grass meadow habitat. Other measures potentially affecting the water budget for the project include gate replacement and installation and piping for water distribution. This water budget is provided to estimate water requirements for the project under two primary scenarios, existing conditions and the Recommended Plan. This analysis may also be used as the basis of water quality assessments for the project and as a tool for project operation.

1.2 Project Area

As discussed in Section 1.3 (main report), the Park is owned by the City of El Paso, El Paso County, TX and is managed by University of Texas at El Paso through its Center for Environmental Resource Management. The Park is located in extreme southeast El Paso and covers an area of approximately 372 acres. Because the Park is enclosed on the east, south and north sides by irrigation canals, drains, and a remnant river bend, it is considered hydraulically isolated and the contributing drainage area to the Park is approximately the same as the Park area during the precipitation events addressed by the water balance. This analysis does not address any high-flow (flooding) conditions at the Park.

The surface areas of the measures from the Recommended Plan were taken from Figure 25 (main report). Existing Conditions for the site are shown on Figure 26 (main report). As discussed in Section 3.4 (main report), the Recommended Plan includes restoration activities over approximately 151 acres. This includes 55.1 acres of existing wetland that will be deepened and lined, 1.4 acres of wetland creation, 34.3 acres of wet marsh creation, 45 acres of riparian habitat creation and 15.3 acres of grassland creation. This water budget classified restoration measures in terms of “wet” areas and “dry” areas. Existing Wetland (E), New Wetlands (W), New Wetland Marsh (M), and Riparian Areas (R) shown in Figure 25 were considered the “wet” areas of the Park. The Grass Meadow (G) was considered a “dry” area of the Park.

1.3 Water Requirements for the Project

The water budget accounted for water consumption and loss in terms of evapotranspiration (ET), and infiltration. These mechanisms were only considered for the “wet” areas of the Park. Specifically, the areas with grass meadow were assumed to be self-sustaining and were excluded from the water budget. The water budget further neglected other losses considered to be minor, such as water leaks through control gates, infiltration along the lined Riverside Canal, and evaporation losses associated with the Park’s internal conveyance system.

Predominant U.S. Department of Agriculture, Natural Resource Conservation Service (USDA-NRCS) soil groups for the project site are shown in Figure 18 and Table 7 from Section 2.12.3 (main report). The existing wetland areas in the Park (Figure 26, main report) lie partly over soils that are mapped with high infiltration rates that would typically be considered unsuitable to sustain wetlands. It therefore appears that the surface soils for these features have been modified with the creation of the existing wetlands. However, detailed infiltration data for these wetlands is not available for this feasibility-level water budget. Section 3.2.1 (main report) indicates that the project will also include lining as needed to reduce water loss through infiltration. For this water budget new constructed wetlands and disturbed areas of the existing wetlands are assumed to be lined with bentonite clay. Infiltration along the internal conveyance ditch is assumed to be small and has been neglected. The internal ESS-13 (a liquid polymer emulsion) is assumed to be utilized in the new marsh areas, along with possible soil augmentation, to improve water retention within these features. The project may also incorporate geosynthetic clay liners (GCL).

1.3.1 Sources of Data

Monthly gross lake evaporation rates for the water budget (**Figure 1**, below) were obtained from the Texas Water Development Board (TWDB). This agency of the Texas state government provides monthly and annual precipitation and lake evaporation rates in a gridded format of one-degree latitude by one-degree longitude quadrangles that cover Texas. Precipitation data are available from 1940 through 2017 and gross lake evaporation data are available from 1954 through 2017. The precipitation and gross lake evaporation data posted by TWDB are based on raw data collected by multiple organizations, processed by the method for spatial distribution as specified on the TWDB web site, and are subject to revision as additional data and/or updates are made available to the TWDB (TWDB, 2018). Gross lake evaporation rates were selected for the water budget rather than net lake evaporation rates (which excludes the precipitation rate over the lake surface) because precipitation is a tracked inflow for the water budget and needed to also be accounted for in the “losses” side of the budget. The median values from **Figure 1** (below) were used for the evaporation rates to reduce the influence of statistical outliers and to provide a more conservative analysis (as the median evaporation rates are slightly higher than the mean values). Calculation of gross lake evaporation for the water budget conservatively assumed that the wet marshes would be inundated year round and contributing to monthly evaporation. Effects of salinity, which would tend to decrease evaporation rates, were neglected for the analysis, as were localized variations in water temperature.

************ Quadrangle: 601 ******************
********** Data Units: Inches *****************
************ Monthly Evap ******************
************ Statistics ******************

n	Min	Max	Median	Mean	10%ile	90%ile
768	1.01	11.17	5.88	5.81	2.58	9.25

Month	n	Min	Max	Median	Mean	10%ile	90%ile
JAN	64	1.24	4.03	2.60	2.59	1.87	3.24
FEB	64	1.67	6.44	3.49	3.46	2.77	4.01
MAR	64	3.32	7.11	5.72	5.53	4.18	6.56
APR	64	4.90	9.26	7.44	7.35	6.33	8.29
MAY	64	2.77	10.34	8.13	8.05	7.07	9.31
JUN	64	5.19	11.17	9.59	9.51	8.50	10.58
JUL	64	5.04	10.89	8.96	8.77	7.50	9.87
AUG	64	3.82	9.45	7.56	7.36	5.95	8.66
SEP	64	3.38	8.12	6.33	6.19	5.04	7.37
OCT	64	2.57	6.71	5.02	4.97	3.88	5.92
NOV	64	1.90	4.41	3.51	3.41	2.54	4.16
DEC	64	1.01	4.57	2.55	2.56	1.78	3.23

************ Annual Evap ******************
************ Statistics ******************

n	Min	Max	Median	Mean	10%ile	90%ile
64	56.99	82.50	70.41	69.81	61.72	78.37

************ Monthly Precip******************
************ Statistics ******************

n	Min	Max	Median	Mean	10%ile	90%ile
936	0.00	7.19	0.67	0.91	0.07	1.98

Month	n	Min	Max	Median	Mean	10%ile	90%ile
JAN	78	0.00	2.57	0.57	0.70	0.08	1.48
FEB	78	0.00	3.42	0.54	0.65	0.07	1.33
MAR	78	0.00	1.94	0.36	0.45	0.01	1.01
APR	78	0.00	1.66	0.34	0.45	0.01	1.05
MAY	78	0.00	2.61	0.55	0.64	0.05	1.38
JUN	78	0.01	4.02	0.67	0.87	0.17	1.79
JUL	78	0.34	6.40	1.46	1.69	0.62	2.99
AUG	78	0.17	4.11	1.40	1.61	0.59	2.93
SEP	78	0.00	7.19	1.21	1.51	0.26	3.31
OCT	78	0.00	3.92	0.74	0.96	0.14	2.17
NOV	78	0.00	2.90	0.48	0.66	0.03	1.62
DEC	78	0.00	3.65	0.64	0.78	0.06	1.44

************ Annual Precip******************
************ Statistics ******************

n	Min	Max	Median	Mean	10%ile	90%ile
78	3.91	20.16	10.22	10.97	6.55	16.00

Figure 1. Monthly Gross Lake Evaporation Rates

Evapotranspiration rates for the water budget were estimated by applying ET vegetation coefficients to a reference crop evapotranspiration rate, ET_0. Average monthly values for ET_0 were obtained from the AgriLife Extension of Texas A&M University (AfriLife) and are shown for the City of El Paso in **Figure 2**. Monthly average ET_0 values for the City of El Paso were based on 52 years of data (AgriLife Extension, Texas A&M University, 2019).

Historic ETo Reference

City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Abilene	2.08	2.57	4.14	5.48	6.47	7.65	8.36	7.46	5.48	4.21	2.67	2.08
Amarillo	1.84	2.27	3.73	5.06	5.89	7.51	8.08	7.29	5.61	4.05	2.40	1.78
Austin	2.27	2.72	4.34	5.27	6.39	7.15	7.22	7.25	5.57	4.38	2.74	2.21
Brownsville	2.65	3.03	4.48	5.17	6.03	6.32	6.68	6.65	5.21	4.34	3.01	2.59
College Station	2.20	2.71	4.22	5.20	6.25	6.89	7.10	6.85	5.60	4.30	2.80	2.20
Corpus Christi	2.42	2.95	4.28	5.17	5.95	6.43	6.68	6.65	5.21	4.34	3.01	2.59
Dallas / Ft Worth	2.00	2.46	3.96	5.14	6.21	7.06	7.40	7.25	5.49	4.19	2.59	2.10
Del Rio	2.47	3.01	4.76	6.01	6.98	7.41	7.57	7.41	5.77	4.35	2.91	2.36
El Paso	2.74	3.53	6.07	8.19	9.83	11.12	9.19	8.94	7.69	5.89	3.58	2.49
Galveston	2.20	2.60	4.10	5.00	6.11	6.60	6.20	6.00	5.50	4.20	2.80	2.30
Houston	2.36	2.83	4.32	5.01	6.11	6.57	6.52	6.08	5.57	4.28	2.90	2.35
Lubbock	2.35	2.63	4.41	5.53	6.93	7.73	7.63	7.20	5.54	4.19	2.61	2.33
Midland	2.20	2.78	4.46	5.91	7.21	8.20	9.23	8.62	6.96	4.31	2.78	2.16
Port Arthur	2.25	2.63	3.95	5.09	6.12	6.60	5.81	5.61	5.46	4.18	2.76	2.23
San Angelo	2.88	3.13	5.31	7.01	8.48	9.16	9.29	8.49	6.60	5.08	3.37	2.54
San Antonio	2.42	2.90	4.42	5.47	6.47	6.97	7.31	6.99	5.64	4.44	2.85	2.36
Victoria	2.35	2.87	4.29	5.77	6.39	6.70	6.92	6.70	5.36	4.41	2.93	2.33
Waco	2.13	2.62	4.03	5.31	6.45	7.15	7.40	7.50	5.70	4.41	2.70	2.17
Wichita Falls	1.94	2.46	4.07	5.50	6.70	7.54	7.97	7.72	5.79	4.30	2.62	1.95

Figure 2. Historic ET_o Rates

ET vegetation coefficients for the El Paso area were obtained from a study prepared for TWDB by the University of Texas at Austin (et al.) and are shown in **Table 1** (below). Vegetation coefficients used in the water budget were 0.77 (wetlands) for wetland and marsh areas and 0.36 (cottonwood) for riparian areas (University of Texas at Austin, et al., 2005).

Table 1. ET Vegetation Coefficients

	Del Rio	Austin	El Paso	Amarillo
wetlands	0.77	0.77	0.77	0.77
saltcedar	0.66	0.66	0.54	0.52
cottonwood	0.40	0.37	0.36	0.34
ranchland: warm grasses	0.74	0.70	0.62	0.53
ranchland: creosote	0.58	0.57	0.56	0.54
mesquite	0.72	0.54	0.53	0.44
pine	0.53	0.53	0.42	0.37
pecan	0.41	0.41	0.37	0.34

As discussed above, detailed infiltration rates for the project site were not available for the feasibility-level analysis and had to be estimated for the water budget. As shown in Table 7 in Section 2.12.3 (main report), predominant existing soils at the project site belong to Hydrologic Soil Groups (HSGs) ranging from 'A' to 'D'. The water budget used saturated hydraulic conductivity (K_{sat}) as an estimate of the infiltration rate for each HSG, as shown in **Table 2** (below). Typical ranges of K_{sat} values were obtained from the U.S. Department of Agriculture (USDA) Soil Survey Geographic Database (USDA, 2013) and K_{sat} values at the upper end of each range were selected for the analysis. The selected values ranged from 0.06 inches per hour (type 'D' soils) to 5.95 inches per hour (type 'A' soils).

It was assumed for the proposed conditions (Recommended Plan) water budget that ESS-13 treatment would reduce infiltration rates to 0.01 inches per hour and that bentonite lining would reduce infiltration rates to $1x10^{-4}$ inches per hour, as shown in **Table 2** (below).

Table 2. Hydrologic Properties of Soil Groups (Ksat values based on USDA, 2013)

Map Unit Symbol	Map Unit Name	Drainage Class	Saturated Hydraulic Conductivity (Ksat, in/hr)	Hydrologic Soil Group	Unified Soil Classification Code	USDA Texture	Assumed Infiltratio0n rate (in/hr)	Assumed Infiltratio0n rate with ESS-13 (in/hr)	Assumed Infiltratio0n rate with Bentonite (in/hr)
An	Anapra silty clay loam	Well Drained	0.20-0.57	C	CL, SM, SP-SM	Silty clay loam, silt loam, clay loam, fine sandy loam	0.57	0.01	0.0001
Gc	Gila loam	Well Drained	0.57-1.98	B	CL,ML,SM	Loam, gravely sandy loam, silt loam	1.98	0.01	0.0001
Ha	Harkey loam	Well Drained	0.20-0.57	C	CL-ML, ML	Loam, very fine sandy loam	0.57	0.01	0.0001
Hk	Harkey silty clay loam	Well Drained	0.20-0.57	C	CL, ML	Silty clay loam, very fine sandy loam	0.57	0.01	0.0001
Mg	Made land, Gila soil material	Well Drained	0.57-1.98	B	ML, SM	Fine sandy loam,loam, gravelly sandy loam, silt loam	1.98	0.01	0.0001
Sa	Saneli silty clay loam	Well drained	0.00-0.06	D	CH, SM	Silty clay loam, fine sand	0.06	0.01	0.0001
Sc	Saneli silty clay	Well drained	0.00-0.06	D	CH, SM	Silty clay, fine sand	0.06	0.01	0.0001
Tg	Tigua silty clay	Well drained	0.00-0.06	D	CH, CL, CL-ML	Silty clay, clay, silt loam	0.06	0.01	0.0001
Vn	Vinton fine sandy loam	Somewhat excessively drained	1.98-5.95	A	ML, SM	Fine sandy loam, loamy sand, fine sand	5.95	0.01	0.0001

1.3.2 <u>Calculation of consumption/loss volumes</u>

Calculations of outflows for the water budget due to consumptive use and evaporation are shown in **Table 3** (below). Areas identified as measures E1 and E2 (rows 12 and 13) correspond to existing site conditions. Proposed measures from the Recommended Plan are designated in the table as described above.

Evaporation and ET losses for wetland and marsh areas (measures E, W, and M) were conservatively estimated using gross lake evaporation rates to reflect losses before the establishment of wetland plants. As shown in **Table 3** (below), monthly loss rates for wetland and marsh areas related to gross lake evaporation (row 4) were consistently higher than those for ET (row 6). Volumes of evaporation in acre-feet for each of the measures were estimated by converting the monthly evaporation rates to feet and multiplying them by the area of each measure in acres.

Losses for riparian areas (measure R) were evaluated both in terms of gross lake evaporation and ET. As shown in **Table 3** (below), monthly loss rates for riparian areas related to gross lake evaporation (row 4) were consistently lower than those for ET (row 7). To produce a more conservative result ET losses for the riparian areas were also estimated by adding monthly median precipitation to ETo (row 8). These most conservative estimates of ET losses were used for the analysis.

Figure 4 of the main report shows that reclaimed wastewater, the primary source of water for the project, will reach the Park by way of a 36-inch pipeline and will inflow directly into existing wetlands E1 and E2. Flow from the pipeline will reach other areas of the Park by way of an internal drainage system. It is anticipated that flow delivered by the internal drainage system will increase ET in the riparian areas. However, the delivery rate of this flow is unknown at this time and will likely be adjusted to account for seasonal variability, the performance of the selected riparian species, and to not over-water the riparian areas. To account for this uncertainty the water budget conservatively assumes that ET for the riparian areas will be double the calculated values from rows 46 through 52 of **Table 3** (below). Volumes of ET in acre-feet for each of the riparian areas were estimated by converting the monthly ET rates to feet and multiplying them by the area of each riparian area in acres.

Table 3. Evaporation and ET Calculations

1	ET Calculations - Recommended Plan																
2				month >	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	annual total
3			ETo		2.74	3.53	6.07	8.19	9.83	11.12	9.19	8.94	7.69	5.89	3.58	2.49	
4	wetland >>		**gross** lake evap, median		2.60	3.49	5.72	7.44	8.13	9.59	8.96	7.56	6.33	5.02	3.51	2.55	70.9
5	riparian >>		cottonwood veg coeff x gross lake evap		0.94	1.26	2.06	2.68	2.93	3.45	3.23	2.72	2.28	1.81	1.26	0.92	25.52
6	wetland >>		marsh veg coefficient x ETo		2.11	2.72	4.67	6.31	7.57	8.56	7.08	6.88	5.92	4.54	2.76	1.92	61.03
7	riparian >>		cottonwood veg coeff x ETo		0.99	1.27	2.19	2.95	3.54	4.00	3.31	3.22	2.77	2.12	1.29	0.90	28.53
8	riparian >>		cottonwood coefficient x (ETo + precip)		1.19	1.47	2.31	3.07	3.74	4.24	3.83	3.72	3.20	2.39	1.46	1.13	31.76
9																	
10	**Wetland ET using Lake Evap**																
11		**acres**		**volume**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	
12	E1	38.5		vol (ac-ft)	8.342	11.197	18.352	23.870	26.084	30.768	28.747	24.255	20.309	16.106	11.261	8.181	227.47
13	E2	16.6		vol (ac-ft)	3.597	4.828	7.913	10.292	11.247	13.266	12.395	10.458	8.757	6.944	4.856	3.528	98.08
14	W2	1.4	wetland estimates using gross	vol (ac-ft)	0.303	0.407	0.667	0.868	0.949	1.119	1.045	0.882	0.739	0.586	0.410	0.298	8.27
16	M1	3.5	lake evap values in row 4	vol (ac-ft)	0.758	1.018	1.668	2.170	2.371	2.797	2.613	2.205	1.846	1.464	1.024	0.744	20.68
17	M2	15.9		vol (ac-ft)	3.445	4.624	7.579	9.858	10.772	12.707	11.872	10.017	8.387	6.652	4.651	3.379	93.94
18	M3	6.2		vol (ac-ft)	1.343	1.803	2.955	3.844	4.201	4.955	4.629	3.906	3.271	2.594	1.814	1.318	36.63
19	M4	8.7		vol (ac-ft)	1.885	2.530	4.147	5.394	5.894	6.953	6.496	5.481	4.589	3.640	2.545	1.849	51.40
20			**monthly subtotal**	vol (ac-ft)	**19.7**	**26.4**	**43.3**	**56.3**	**61.5**	**72.6**	**67.8**	**57.2**	**47.9**	**38.0**	**26.6**	**19.3**	**536.6**
21																	
22	**RiparianET using Lake Evap**																
23		**acres**		**volume**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	
24	R1	8.9		vol (ac-ft)	0.694	0.932	1.527	1.986	2.171	2.561	2.392	2.019	1.690	1.340	0.937	0.681	18.93
25	R2	9.0		vol (ac-ft)	0.702	0.942	1.544	2.009	2.195	2.589	2.419	2.041	1.709	1.355	0.948	0.689	19.14
26	R3	3.1	riparian estimates using veg	vol (ac-ft)	0.242	0.325	0.532	0.692	0.756	0.892	0.833	0.703	0.589	0.467	0.326	0.237	6.59
27	R4	4.6	coeff x gross lake evap; values in	vol (ac-ft)	0.359	0.482	0.789	1.027	1.122	1.323	1.236	1.043	0.874	0.693	0.484	0.352	9.78
28	R5	3.9	row 5	vol (ac-ft)	0.304	0.408	0.669	0.870	0.951	1.122	1.048	0.885	0.741	0.587	0.411	0.298	8.30
29	R6	9.5		vol (ac-ft)	0.741	0.995	1.630	2.120	2.317	2.733	2.554	2.155	1.804	1.431	1.000	0.727	20.21
30	R7	6.0		vol (ac-ft)	0.468	0.628	1.030	1.339	1.463	1.726	1.613	1.361	1.139	0.904	0.632	0.459	12.76
31			**monthly subtotal**	vol (ac-ft)	**3.5**	**4.7**	**7.7**	**10.0**	**11.0**	**12.9**	**12.1**	**10.2**	**8.5**	**6.8**	**4.7**	**3.4**	**95.5**
32																	
33	**Riparian ET using (ETo)**																
34		**acres**		**volume**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	
35	R1	8.9		vol (ac-ft)	0.732	0.943	1.621	2.187	2.625	2.969	2.454	2.387	2.053	1.573	0.956	0.665	21.16
36	R2	9.0		vol (ac-ft)	0.740	0.953	1.639	2.211	2.654	3.002	2.481	2.414	2.076	1.590	0.967	0.672	21.40
37	R3	3.1	riparian estimates using veg	vol (ac-ft)	0.255	0.328	0.565	0.762	0.914	1.034	0.855	0.831	0.715	0.548	0.333	0.232	7.37
38	R4	4.6	coeff x ETo; values in row 7	vol (ac-ft)	0.378	0.487	0.838	1.130	1.357	1.535	1.268	1.234	1.061	0.813	0.494	0.344	10.94
39	R5	3.9		vol (ac-ft)	0.321	0.413	0.710	0.958	1.150	1.301	1.075	1.046	0.900	0.689	0.419	0.291	9.27
40	R6	9.5		vol (ac-ft)	0.781	1.006	1.730	2.334	2.802	3.169	2.619	2.548	2.192	1.679	1.020	0.710	22.59
41	R7	6.0		vol (ac-ft)	0.493	0.635	1.093	1.474	1.769	2.002	1.654	1.609	1.384	1.060	0.644	0.448	14.27
42			**monthly subtotal**	vol (ac-ft)	**3.7**	**4.8**	**8.2**	**11.1**	**13.3**	**15.0**	**12.4**	**12.1**	**10.4**	**8.0**	**4.8**	**3.4**	**107.2**
43																	
44	**Riparian ET using (ETo + precip)**																
45		**acres**		**volume**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	
46	R1	8.9		vol (ac-ft)	0.884	1.087	1.717	2.278	2.771	3.148	2.844	2.761	2.376	1.770	1.084	0.836	23.55
47	R2	9.0		vol (ac-ft)	0.894	1.099	1.736	2.303	2.803	3.183	2.876	2.792	2.403	1.790	1.096	0.845	23.82
48	R3	3.1	riparian estimates using veg	vol (ac-ft)	0.308	0.379	0.598	0.793	0.965	1.096	0.990	0.962	0.828	0.617	0.378	0.291	8.20
49	R4	4.6	coeff x ETo; values in row 8	vol (ac-ft)	0.457	0.562	0.887	1.177	1.432	1.627	1.470	1.427	1.228	0.915	0.560	0.432	12.17
50	R5	3.9		vol (ac-ft)	0.387	0.476	0.752	0.998	1.214	1.379	1.246	1.210	1.041	0.776	0.475	0.366	10.32
51	R6	9.5		vol (ac-ft)	0.943	1.160	1.833	2.431	2.958	3.360	3.035	2.947	2.537	1.890	1.157	0.892	25.14
52	R7	6.0		vol (ac-ft)	0.596	0.733	1.157	1.535	1.868	2.122	1.917	1.861	1.602	1.193	0.731	0.563	15.88
53			**monthly subtotal**	vol (ac-ft)	**4.5**	**5.5**	**8.7**	**11.5**	**14.0**	**15.9**	**14.4**	**14.0**	**12.0**	**9.0**	**5.5**	**4.2**	**119.20**
54																	
55	**Total ET (wetland evaporation + 2 x riparian ET)**																
56					**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	
57			**monthlytotal**	vol (ac-ft)	**28.7**	**37.4**	**60.7**	**79.3**	**89.5**	**104.4**	**96.6**	**85.2**	**71.9**	**56.0**	**37.6**	**27.7**	**775.0**

It was assumed for the water budget that infiltration rates would be uniform throughout the year and that the water table would be low enough to allow for year-round infiltration.

Infiltration losses for existing conditions were estimated by characterizing the soil type for each of the existing wetlands, converting the infiltration rate for the corresponding HSG to units of feet per acre per month, then multiplying that infiltration rate by the total area of each wetland to obtain infiltration losses in acre-feet per month. The resulting estimated uniform infiltration loss of approximately 8,500 acre-feet per month is shown in **Table 4** (below). As discussed above, this infiltration loss would appear too high to support the presence of the existing wetlands, but is being used in the feasibility-level water budget until better data becomes available.

Table 4. Estimated Infiltration - Existing Conditions

1	**Infiltration Calculations - Existing Conditions**								
2									
3	**Measure**	**acres**	**Map Unit Symbol**	**Hydrologic Soil Group**	**Approximate Percent**	**Infiltration rate - soil (in/hr/ac)**	**Infiltration rate - measure (in/hr/ac)**	**Infiltration rate - measure (ft/month/ac)**	**Infiltration rate - measure (acre-ft /month)**
4	E1	38.5	Sa	D	24%	0.06	2.93	175.59	6760.2
5			Vn	A	39%	5.95			
6			Ha	C	8%	0.57			
7			Gc	B	20%	1.98			
8			An	C	2%	0.57			
9			Mg	B	7%	1.98			
10	E2	16.6	Mg	B	83%	1.98	1.74	104.42	1733.4
11			Ha	C	17%	0.57			
12	**MONTHLY INFILTRATION (ACRE-FT)**								8494

Estimates of infiltration rates for the Recommended Plan are shown in **Table 5** (below). Infiltration losses were estimated by assuming an infiltration rate to reflect either ESS-13 application or bentonite lining. These rates were then converted for each measure to units of feet per acre per month and multiplied by the total area of the measure to obtain infiltration rates as acre-feet per month. It was estimated that infiltration rates for wetland areas (measures E and W) could be reduced to approximately $1x10^{-4}$ inches per hour and those for marsh areas (measure M) could be reduced to approximately 0.01 inches per hour. It was also assumed that water will only be stored in the wetland areas E1 and E2 and delivered to riparian areas (measures R1 through R7) by the internal drainage system through the Park. Since water is not being stored within the riparian areas the infiltration rates for these measures were set to zero. The water budget assumed that the new wetland, W2, would store water and contribute to infiltration losses.

This analysis resulted in an estimated uniform infiltration loss of approximately 20.9 acre-feet per month. Note that the Recommended Plan has since been revised to incorporate bentonite liners with a lower estimated infiltration rate of $1x10^{-7}$ inches per hour (USDA, 2009), supplemented with GCLs to further decrease infiltration rates. These design revisions make the water budget more conservative with respect to infiltration. It is recommended that the water budget be updated with these revised infiltration rates during final design.

The water requirements for the project are summarized for existing conditions and the Recommended Plan, respectively, in **Table 6** and **Table 7** (below).

Table 5. Estimated Infiltration – Recommended Plan

1	**Infiltration Calculations - Recommended Plan**								
2									
3	Measure	acres	Map Unit Symbol	Hydrologic Soil Group	Approximate Percent	Infiltration rate - soil (in/hr/ac)	Infiltration rate - measure (in/hr/ac)	Infiltration rate - measure (ft/month/ac)	Infiltration rate - measure (acre-ft /month)
4	E1	38.5	Sa	D	24%	0.0001	0.0001	0.006	0.2
5			Vn	A	39%	0.0001			
6			Ha	C	8%	0.0001			
7			Gc	B	20%	0.0001			
8			An	C	2%	0.0001			
9			Mg	B	7%	0.0001			
10	E2	16.6	Mg	B	83%	0.0001	0.0001	0.006	0.1
11			Ha	C	17%	0.0001			
12	W2	1.4	Mg	B	100%	0.0001	0.0001	0.006	0.01
13	M1	3.5	Sc	D	59%	0.01	0.01	0.60	2.1
14			Ha	C	41%	0.01			
15	M2	15.9	Sc	D	70%	0.01	0.01	0.60	9.5
16			Mg	B	30%	0.01			
17	M3	6.2	Ha	C	90%	0.01	0.01	0.60	3.7
18			Mg	B	10%	0.01			
19	M4	8.7	Mg	B	100%	0.01	0.01	0.60	5.2
20	R1	8.9	Ha	C	77%	0	0.00	0.00	0.0
21			Mg	B	1%	0			
22			Sa	D	22%	0			
23	R2	9.0	Hk	C	5%	0	0.00	0.00	0.0
24			Tg	D	60%	0			
25			Mg	B	5%	0			
26			Ha	C	30%	0			
27	R3	3.1	Mg	B	100%	0	0.00	0.00	0.0
28	R4	4.6	An	C	33%	0	0.00	0.00	0.0
29			Vn	A	8%	0			
30			Hk	C	59%	0			
31	R5	3.9	An	C	96%	0	0.00	0.00	0.0
32			Gc	B	1%	0			
33			Sc	D	3%	0			
34	R6	9.5	Ha	C	35%	0	0.00	0.00	0.0
35			An	C	5%	0			
36			Vn	A	60%	0			
37	R7	6.0	Gc	B	39%	0	0.00	0.00	0.0
38			Vn	A	53%	0			
39			Mg	B	8%	0			
40	**MONTHLY INFILTRATION (ACRE-FT)**								20.9

Table 6. Monthly Water Budget Outflows for Existing Conditions

Requirements (acre-feet)	JAN	FEB	MAT	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Evapotranspiration	11.9	16.0	26.3	34.2	37.3	44.0	41.1	34.7	29.1	23.1	16.1	11.7
Infiltration	8494	8494	8494	8494	8494	8494	8494	8494	8494	8494	8494	8494
TOTAL REQUIREMENT	**8,505.9**	**8,510.0**	**8,520.3**	**8,528.2**	**8,531.3**	**8,538.0**	**8,535.1**	**8,528.7**	**8,523.1**	**8,517.1**	**8,510.1**	**8,505.7**

Table 7. Monthly Water Budget Outflows for Recommended Plan

Requirements (acre-feet)	JAN	FEB	MAT	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Evapotranspiration	28.7	37.4	60.7	79.3	89.5	104.4	96.6	85.2	71.9	56.0	37.6	27.7
Infiltration	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9
TOTAL REQUIREMENT	**49.6**	**58.3**	**81.6**	**100.2**	**110.4**	**125.3**	**117.5**	**106.1**	**92.8**	**76.9**	**58.5**	**48.6**

1.4 Water Supply for the Project

The water budget considers four sources of water available to the Park, as discussed in Section 2 (main report): monthly precipitation, irrigation water, reclaimed wastewater and well water. Because all four of these sources may vary annually, the water budget includes optional multipliers to adjust the anticipated inflow from each source. The water budget also includes a column to input concentrations (loadings) for water quality parameters of interest (salinity, nitrates, phosphates, etc.) for each water source.

As discussed in Section 2.1 (main report), monthly pan evaporation rates at the Park may exceed precipitation by an order of magnitude. For this reason precipitation was not considered to be a major inflow to the water budget and is included only to evaluate water quality impacts to the Park. Only precipitation falling directly onto the "wet" areas of the Park is included in the water budget, not that for the entire contributing watershed. Neglecting the precipitation onto the "dry" areas of the Park is consistent with the consumption/loss calculations (above) which only consider ET and infiltration from "wet" areas of the Park.

The remaining three inflows used in the water balance, irrigation water, reclaimed wastewater and well water, are discussed in Section 2.2 (main report). Irrigation water provided by the El Paso County Water Improvement District (EPWID No. 1) became available in 2017 when 304.03 acres of additional Park land was reclassified as irrigable, bringing the total irrigable land to 348.26 acres. The amount of water available to EPWID#1 for irrigation may vary from year to year, depending on volumes in storage in Elephant Butte Reservoir.

The largest water source by flow rate, when available, is reclaimed wastewater provided to the Park by the Bustamante wastewater treatment plant (WWTP), which is operated by the non-federal project sponsor, El Paso Water Utilities (EPWU). The plant, located immediately north of the Park, originally delivered water to the Park through underground conduits and open earth-lined canals. In 2014, a new, buried, 36-inch pipeline was constructed to convey water to the Park from the existing 48-inch WWTP west discharge line.

There are two wells located within the Park boundary. These are outfitted with submersible electric pumps. These wells were evaluated individually in the water budget to allow for evaluation of future scenarios regarding the availability of groundwater and to evaluate water quality.

The two windmills in the park are expected to provide a very small quantity of water, each producing less than 5 gallons per minute (GPM). Inflow from these windmills has therefore been excluded from the water budget.

1.4.1 Sources of Data

As noted above, the monthly median precipitation rates (**Figure 1**, above) used for the water budget were obtained from the TWDB and are based on a period of record from 1940 through 2017 (TWDB, 2018).

As discussed in Sections 1.3 and 2.2 (main report), 348.26 acres of the Park is classified as irrigable land. This consists of 304.03 acres of the Park land that was classified as irrigable in 2017 and 44.23 acres within the Park that were already classified as irrigable. The full allocation of irrigation water that the Park may receive during the irrigation season (mid-February through mid-October) is 4 acre-feet per acre (1,393 acre-feet in total).

As also discussed in Section 2.2 (main report), the largest water source by flow rate, when available, is reclaimed wastewater with a minimum guaranteed flow of approximately 2 million gallons per day (MGD) during the irrigation season. Mr. Gilbert Trejo, P.E., Chief Technical Officer, Technical Services Division, EPWU, detailed the availability of effluent over four operation seasons in his July 15, 2015 email to USACE, This information is summarized below in **Table 8**. From mid-February through mid-October effluent is provided to the project from the Bustamante WWTP through the new pipeline. For the remainder of the year effluent is instead provided via the Riverside Canal.

Table 8. Availability of Reclaimed Water from WWTP

				Effluent Availability by Season			
				effluent (MGD)		effluent (acre-feet)	
Operation Season	Start	End	No. Days	min	max	min	max
Irrigation Season	15-Feb	30-Apr	75	2	4.2	460	966
Peak Irrigation Season	1-May	30-Sep	153	2	4.2	938	2000
Irrigation Season	1-Oct	15-Oct	15	2	4.2	92	193
Non-Irrigation Season	16-Oct	14-Feb	121	*	9.4**	*	3500**

* Information Not Detailed in July 2015 correspondence
** effluent provided via the Riverside Canal; all other flows via EPWU pipeline

John Sproul, the Rio Bosque Wetlands Park Manager, explained in his January 16, 2017 email to USACE that there is a 15 Jan 2015 Memorandum of Understanding (MOU) between [El Paso] Water and El Paso County Water Improvement District #1 which states that 2,000 acre-feet of effluent available to EPWU may be delivered to Rio Bosque Park during the months of May, June, July, August, and September of each year (USACE, 2017).

Mr. Sproul further clarified in his March 14, 2019 email to USACE that since 2015 all effluent has typically been delivered to the Park via the pipeline, not the Riverside Canal. He also stated that 2,000 acre-feet of effluent was typically delivered to the Park during the 5-month period governed by the MOU, but little or no effluent was typically available in February, March, April, and October. In winter the Park receives as much water as needed via the pipeline to fully flood the wetland cells. The pipeline capacity is estimated by EPWU to be 12.41 MGD (USACE, 2019).

As also discussed in Section 2.2 (main report), there are two wells located within the project boundary on opposite corners of the Park. The wells, designated RB-12B and RB-13, are each outfitted with submersible electric pumps and produce approximately 400 GPM. The wells are operated throughout most of the year with only weekly or biweekly overnight rest periods, except during the portion of the non-irrigation season when water from the Bustamante WWTP is delivered to the Park.

1.4.2 Calculation of Inflows

Precipitation volumes for the project were estimated by converting monthly median precipitation rates from **Figure 1** (above) to feet and multiplying them by the “wet” project area of 139.3 acres. This volume was considered to be 100-percent available for the water budget.

Inflows of irrigation water were assumed to be uniformly distributed temporally throughout the irrigation season from mid-February through mid-October. This resulted in a maximum of 175 acre-feet for March through September and a maximum of 87 acre-feet in February and October. Because availability of irrigation water may vary considerably depending on supply, the water budget first solves for the project water requirements, then has the user estimate the required allocation (percentage available) to meet this requirement. The analysis for this appendix assumes a 25-percent allocation of irrigation water, except as noted in Section 1.7.

The minimum flow rate of effluent from the MOU (2 MGD) was assumed to be available during the peak irrigation season from May until September. This equated to approximately 6.1 acre-feet per day for a total volume of 938 acre-feet. During the months of February, March, April, and October effluent was assumed to be unavailable. For the (winter) months of November through January the effluent inflow was estimated at 12.41 MGD, which equated to approximately 38.1 acre-feet per day for a total volume of 3,543 acre-feet (approximately matching the maximum value from **Table 8**, above). This total volume was considered to be 100-percent available for the water budget.

The two wells were evaluated individually in the water budget to accommodate future scenarios regarding the availability of groundwater and to evaluate water quality. Groundwater was assumed to be available during the non-irrigation season from mid-October through mid-February. Pumps were assumed to run 160 hours each week and to be shut down approximately 8 hours each week. Volumes of groundwater from each pump were estimated to be 1.69 acre-feet per day for a total annual volume of 416 acre-feet. This total volume was considered to be 100-percent available for the water budget.

Inflow from these windmills has been excluded from the water budget.

Calculations of inflows for the water budget from the four sources discussed above are shown below in **Table 9** and **Table 10** (below), respectively, for existing site conditions and the Recommended Plan.

Table 9. Monthly Inflows for Existing Conditions

Supply (acre-feet)	% available	WQ loading	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Precipitation	100%		2.6	2.5	1.7	1.6	2.5	3.1	6.7	6.4	5.6	3.4	2.2	2.9
Irrigation Water	25%		-	22	44	44	44	44	44	44	44	22	-	-
Effluent	100%		1,181	-	-	-	190	184	190	190	184	-	1,181	1,181
Well RB-12	100%		52.4	25.4	-	-	-	-	-	-	-	25.4	52.4	52.4
Well RB-13	100%		52.4	25.4	-	-	-	-	-	-	-	25.4	52.4	52.4
Windmills	0%		-	-	-	-	-	-	-	-	-	-	-	-
TOTAL SUPPLY			**1,288.4**	**75.1**	**45.4**	**45.3**	**236.2**	**230.7**	**240.4**	**240.1**	**233.2**	**76.0**	**1,288.0**	**1,288.7**

Table 10. Monthly inflows for Recommended Plan

Supply (acre-feet)	% available	WQ loading	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Precipitation	100%		6.6	6.3	4.2	3.9	6.4	7.8	16.9	16.3	14	8.6	5.6	7.4
Irrigation Water	25%		-	22	44	44	44	44	44	44	44	22	-	-
Effluent	100%		1,181	-	-	-	190	184	190	190	184	-	1,181	1,181
Well RB-12	100%		52.4	25.4	-	-	-	-	-	-	-	25.4	52.4	52.4
Well RB-13	100%		52.4	25.4	-	-	-	-	-	-	-	25.4	52.4	52.4
Windmills	0%		-	-	-	-	-	-	-	-	-	-	-	-
TOTAL SUPPLY			**1,292.4**	**78.9**	**47.9**	**47.6**	**240.1**	**235.4**	**250.6**	**250.0**	**241.6**	**81.2**	**1,291.4**	**1,293.2**

1.5 Existing Conditions Water Budget

For the reasons discussed above this water budget cannot accurately estimate infiltration rates for the existing wetlands. The calculated infiltration losses included in the analysis, based on mapped surface soils, appear too large to support the presence of the existing wetlands. It is therefore recommended that the existing conditions analysis included in this appendix be revised when better infiltration data becomes available.

1.5.1 Summary of Existing Conditions

"Wet" areas of the Park included in the existing conditions analysis were limited to the two existing wetlands (E1 and E2) which were used as the basis of the estimated values for the two outflows and the precipitation inflow for the water budget. The other inflows to the water budget (effluent, irrigation, and groundwater from windmills) did not differ between existing conditions and the Recommended Plan.

1.5.2 Results of Existing Conditions Analysis

Table 11 (below) summarizes water supply, water requirements, and surplus/deficit for the project area on a monthly basis. The table shows that the largest inflows to the Park come from effluent and that precipitation is a comparatively minor source of water for the project. Though this analysis conservatively assumed that only 25-percent of the allocated irrigation water was available, fully allocated irrigation inflows could be comparable to those of effluent during the peak irrigation season (May through September). Groundwater from the two wells is the primary source of inflow during February and October, but is only a little over half of the inflow from effluent during the peak irrigation season.

Reliable conclusions cannot be drawn regarding existing conditions project outflows due to uncertainties regarding infiltration.

Table 11. Monthly Water Surplus/Deficit for Existing Conditions

Supply (acre-feet)	% available	WQ loading	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Precipitation	100%		2.6	2.5	1.7	1.6	2.5	3.1	6.7	6.4	5.6	3.4	2.2	2.9
Irrigation Water	25%		-	22	44	44	44	44	44	44	44	22	-	-
Effluent	100%		1,181	-	-	-	190	184	190	190	184	-	1,181	1,181
Well RB-12	100%		52.4	25.4	-	-	-	-	-	-	-	25.4	52.4	52.4
Well RB-13	100%		52.4	25.4	-	-	-	-	-	-	-	25.4	52.4	52.4
Windmills	0%		-	-	-	-	-	-	-	-	-	-	-	-
TOTAL SUPPLY			**1,288.4**	**75.1**	**45.4**	**45.3**	**236.2**	**230.7**	**240.4**	**240.1**	**233.2**	**76.0**	**1,288.0**	**1,288.7**

Requirements (acre-feet)	JAN	FEB	MAT	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Evapotranspiration	11.9	16.0	26.3	34.2	37.3	44.0	41.1	34.7	29.1	23.1	16.1	11.7
Infiltration	8494	8494	8494	8494	8494	8494	8494	8494	8494	8494	8494	8494
TOTAL REQUIREMENT	**8,505.9**	**8,510.0**	**8,520.3**	**8,528.2**	**8,531.3**	**8,538.0**	**8,535.1**	**8,528.7**	**8,523.1**	**8,517.1**	**8,510.1**	**8,505.7**

	JAN	FEB	MAT	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MONTHLY SURPLUS (acre-feet)	**(7,217.5)**	**(8,434.9)**	**(8,474.9)**	**(8,482.9)**	**(8,295.1)**	**(8,307.3)**	**(8,294.7)**	**(8,288.6)**	**(8,289.9)**	**(8,441.1)**	**(7,222.1)**	**(7,217.0)**

A summary of existing conditions site information and annual inflows and outflows is shown in **Figure 3** (below).

Water Budget for El Paso Rio Bosque Wetlands Park
Existing Conditions

Project:	El Paso Rio Bosque Wetlands Section 206 Ecosystem Restoration
Location:	El Paso, Texas
Calculated by:	Jame Eisenberg, PE, Hydraulic Engineer Dana Price, Biologist Carlos Aragon, PE, Geotechnical Engineer
Date of calculations:	2-May-19
Modified by:	
Date modified:	

Summary					
	Annual Requirement	33,319.5	gallons x 10^6	126.08	m3 x 10^6
	Annual Supply	1,723.0	gallons x 10^6	6.26	m3 x 10^6
Site Information					
	Park Area	372	acres	1.51	km2
	"Dry" Park Area	316.9	acres	1.28	km2
	"Wet" Park Area	55.1	acres	0.22	km2
	Existing Wetland	55.1	acres	0.22	km2
	New Wetland	0	acres	0	km2
	New Marsh	0	acres	0	km2
	New Cottonwood-Willow Habitat	0	acres	0	km2
Supply (Annual)					
	Precipitation	13.4	gallons x 10^6	0.05	m3 x 10^6
	Surface Inflow - Riverside Canal 25%	113.9	gallons x 10^6	0.43	m3 x 10^6
	Surface Inflow - effluent from Bustamante WWTP	1,460.1	gallons x 10^6	5.52	m3 x 10^6
	Groundwater - wells	135.6	gallons x 10^6	0.26	m3 x 10^6
	Groundwater - windmills	-	gallons x 10^6	-	m3 x 10^6
Requirement (Annual)					
	Evapotranspiration	106.1	gallons x 10^6	0.40	m3 x 10^6
	Infiltration	33,213	gallons x 10^6	125.7	m3 x 10^6

Figure 3. Summary of Water Budget for Existing Conditions

1.6 Water Budget for the Recommended Plan

The water budget for the Recommended Plan indicates that sufficient water is available to support the proposed modification of existing wetlands, construction of new wetlands, construction of new wet marshes, and enhancement of riparian habitat at the Park. It also highlights the necessity of reducing the infiltration rates for "wet" Park areas and of providing sufficient volume for water storage during the period from February to May.

1.6.1 Summary of Proposed Conditions

"Wet" areas of the Park included in the proposed conditions analysis include the two existing wetlands (E1 and E2), the proposed wetland (W2), the proposed wet marshes (M1 through M4), and proposed riparian habitat (R1 through R7). The proposed project increases the "wet" area of the Park from 55.1 acres to 135.8 acres, also increasing the estimated amounts of the two outflows in the water budget and the precipitation inflows. The other inflows to the water budget (effluent, irrigation, and groundwater from windmills) did not differ between existing conditions and the recommended plan.

1.6.2 Results of Proposed Conditions Analysis

Table 12 (below) summarizes water supply, water requirements, and surplus/deficit for the project area on a monthly basis. Also included is the monthly change to assumed project storage in acre-feet. This storage should only be considered a representative value and was estimated at approximately 300 acre-feet. This same information is shown graphically in **Figure 4** (below).

Table 12. Monthly Water Surplus/Deficit for Recommended Plan

Supply (acre-feet)	% available	WQ loading	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Precipitation	100%		6.5	6.1	4.1	3.8	6.2	7.6	16.5	15.8	13.7	8.4	5.4	7.2
Irrigation Water	25%		-	22	44	44	44	44	44	44	44	22	-	-
Effluent	100%		1,181	-	-	-	190	184	190	190	184	-	1,181	1,181
Well RB-12	100%		52.4	25.4	-	-	-	-	-	-	-	25.4	52.4	52.4
Well RB-13	100%		52.4	25.4	-	-	-	-	-	-	-	25.4	52.4	52.4
Windmills	0%		-	-	-	-	-	-	-	-	-	-	-	-
TOTAL SUPPLY			**1,292.3**	**78.7**	**47.8**	**47.5**	**239.9**	**235.2**	**250.2**	**249.5**	**241.3**	**81.0**	**1,291.2**	**1,293.0**

Requirements (acre-feet)	JAN	FEB	MAT	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Evapotranspiration	28.7	37.4	60.7	79.3	89.5	104.4	96.6	85.2	71.9	56.0	37.6	27.7
Infiltration	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9
TOTAL REQUIREMENT	**49.6**	**58.3**	**81.6**	**100.2**	**110.4**	**125.3**	**117.5**	**106.1**	**92.8**	**76.9**	**58.5**	**48.6**

	JAN	FEB	MAT	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MONTHLY SURPLUS (acre-feet)	**1,242.7**	**20.4**	**(33.8)**	**(52.7)**	**129.5**	**109.9**	**132.7**	**143.4**	**148.5**	**4.1**	**1,232.7**	**1,244.4**
POTENTIAL WETLAND STORAGE (acre-feet)	**300.0**	**300.0**	**266.2**	**213.5**	**300.0**	**300.0**	**300.0**	**300.0**	**300.0**	**300.0**	**300.0**	**300.0**

Many of the conclusions derived from **Table 12** and **Figure 4** match those from the existing conditions water budget. The analysis shows that the largest inflows to the Park come from effluent and that precipitation is a comparatively minor source of water for the project. Though this analysis conservatively assumed that only 25-percent of the allocated irrigation water was available, fully allocated irrigation inflows could be comparable to those of effluent during the peak irrigation season (May through September). Groundwater from the two wells is the primary source of inflow during February and October, but is only a little over half of the effluent inflow during the peak irrigation season. "Flushing" of the Park to improve water quality would likely need to be performed in March or April, which is also when storage in the wetland is near its lowest volume.

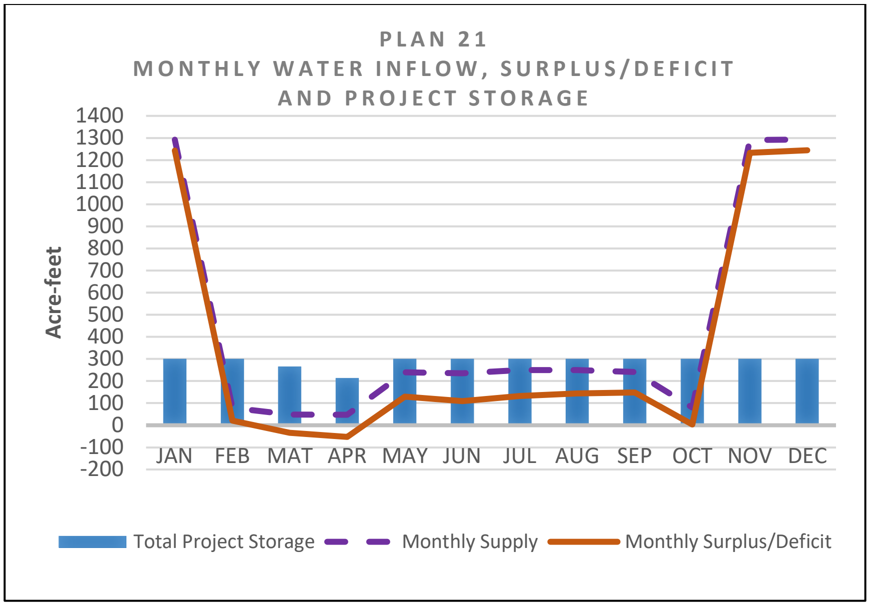

Figure 4 Monthly Water Surplus/Deficit for Recommended Plan

Table 12 and **Figure 4** (above) show that "wet" areas of the project should be filled to capacity at the beginning of the calendar year due to the availability of large amounts of effluent between November and January. During the months of February through April Mr. Sproul reported minimal effluent inflows, and the volume of stored water is expected to decrease. Water storage is expected to be at a minimum in April, then increase as effluent inflows resume during the peak irrigation season. Full storage capacity for the Park is estimated to be restored by May. Water supply will only slightly exceed project needs in October due to decreased supply of effluent, but the project will have surplus inflow for the last two months of the year when effluent supply is restored.

This feasibility-level analysis highlights the need to provide adequate storage volume in the wetland and marsh areas (approximately 90 acre-feet) to keep the Park from completely drying when effluent inflow is most limited. Note that this analysis conservatively assumed that only 25-percent of irrigation water would be available in any given year. This assumption is readdressed in Section 1.7 (below).

A summary of proposed conditions site information and annual inflows and outflows is shown in **Figure 5** (below).

Water Budget for El Paso Rio Bosque Wetlands Park
With-Project Conditions, Recommended Plan

Project:	El Paso Rio Bosque Wetlands Section 206 Ecosystem Restoration
Location:	El Paso, Texas
Calculated by:	Jame Eisenberg, PE, Hydraulic Engineer
	Dana Price, Biologist
	Carlos Aragon, PE, Geotechnical Engineer
Date of calculations:	2-May-19
Modified by:	
Date modified:	

Summary						
	Annual Requirement		334.3	gallons x 10^6	1.26	m3 x 10^6
	Annual Supply		1,742.6	gallons x 10^6	6.34	m3 x 10^6
Site Information						
	Park Area		372	acres	1.51	km2
	"Dry" Park Area		236.2	acres	0.96	km2
	"Wet" Park Area		135.8	acres	0.55	km2
	Existing Wetland		55.1	acres	0.22	km2
	New Wetland		1.4	acres	0.01	km2
	New Marsh		34.3	acres	0.14	km2
	New Cottonwood-Willow Habitat		45	acres	0.18	km2
Supply (Annual)						
	Precipitation		33.0	gallons x 10^6	0.12	m3 x 10^6
	Surface Inflow - Riverside Canal	25%	113.9	gallons x 10^6	0.43	m3 x 10^6
	Surface Inflow - effluent from Bustamante WWTP		1,460.1	gallons x 10^6	5.52	m3 x 10^6
	Groundwater - wells		135.6	gallons x 10^6	0.26	m3 x 10^6
	Groundwater - windmills		-	gallons x 10^6	-	m3 x 10^6
Requirement (Annual)						
	Evapotranspiration		252.5	gallons x 10^6	0.96	m3 x 10^6
	Infiltration		82	gallons x 10^6	0.3	m3 x 10^6

Figure 5. Summary of Water Budget for Recommended Plan

1.7 Limited Recommended Plan Sensitivity Analysis

A limited sensitivity analysis was performed to evaluate assumptions made for the Recommended Plan water budget regarding assumed infiltration rates and the availability of irrigation water. Though this evaluation was extremely limited in scope, it yielded information that may aid in the selection of lining materials for the project and illustrates how the water budget may be used to evaluate specific design elements of the Recommended Plan.

As discussed in Section 1.3 of this appendix, estimated infiltration rates based on HSGs result in infiltration losses that appear too large to support the development of wetlands at the Park. Accordingly, infiltration rates for the recommended plan will be reduced by lining the new wetland areas and the disturbed portions of existing wetland areas with bentonite and by utilizing ESS-13, possibly combined with soil augmentation, in the new marsh areas. The project may also incorporate synthetic liners. It was anticipated for the water budget that infiltration rates for wetland areas (measures E and W) could be reduced to approximately $1x10^{-4}$ inches per hour and those for marsh areas (measure M) could be reduced to approximately 0.01 inches per hour. Actual achievable infiltration rates will not be known until a detailed geotechnical analysis is completed.

To account for possible drought conditions the water budget assumed that only 25-percent of irrigable water would be available in a typical year. As discussed in Section 1.4 of this appendix, the Park includes 304.03 acres of land that was reclassified as irrigable in 2017 and 44.23 acres that was previously classified as irrigable. The full allocation of irrigation water that the Park may receive during the irrigation season (mid-February through mid-October) is 4 acre-feet per acre, summing to 1,393 acre-feet, which could be comparable to those of effluent during the peak irrigation season.

The limited sensitivity analysis analyzed infiltration rates ranging from $1x10^{-8}$ to 0.05 inches per hour. It also considered multiple allocations of irrigation water to represent drought tolerance for the wetlands. Results of the limited sensitivity analysis are shown in **Table 13** (below) and described in more detail below.

Table 13 Limited Sensitivity Analysis

Trial No.	Irrigation Allocation (%)	Achievable infiltration rates (in/hr)			Monthly Infiltration	Required Park Storage
		E	W	M	(acre-feet)	(acre-feet)
1	25	$1x10^{-8}$	$1x10^{-8}$	0.01	20.6	89.5
2	25	$1x10^{-4}$	$1x10^{-4}$	0.01	20.9	90.1
3	25	0.01	0.01	0.01	56.6	177.6
4	25	0.02	0.02	0.02	113.2	347.4
5	50	0.02	0.02	0.02	113.2	238.1
6	50	0.03	0.03	0.03	169.7	407.6
7	75	0.03	0.03	0.03	169.7	298.4
8	25	0.01	0.01	0.02	77.2	239.4
9	25	0.01	0.01	0.03	97.7	300.9
10	50	0.01	0.01	0.05	138.9	315.2
11	50	$1x10^{-4}$	$1x10^{-4}$	0.05	103.3	208.4
12	50	$1x10^{-4}$	$1x10^{-4}$	0.1	206.2	731.8

1.7.1 Analytical Procedure

Example calculations for Trials 2 through 5 are shown in **Table 14** (below) and discussed below.

Table 14 Examples of Sensitivity Calculations

Trial 2	JAN	FEB	MAT	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
TOTAL SUPPLY (acre-feet)	1,292.4	78.9	47.9	47.6	240.1	235.4	250.6	250.0	241.6	81.2	1,291.4	1,293.2
TOTAL REQUIREMENT (acre-feet)	50.3	59.3	83.2	102.4	112.8	128.1	120.1	108.3	94.6	78.3	59.5	49.3
MONTHLY SURPLUS (acre-feet)	1,242.1	19.6	(35.3)	(54.8)	127.3	107.3	130.5	141.7	147.0	2.9	1,231.9	1,243.9
POTENTIAL WETLAND STORAGE (acre-feet)	300.0	300.0	264.7	209.9	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0
Trial 3	JAN	FEB	MAT	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
TOTAL SUPPLY (acre-feet)	1,292.4	78.9	47.9	47.6	240.1	235.4	250.6	250.0	241.6	81.2	1,291.4	1,293.2
TOTAL REQUIREMENT (acre-feet)	86.0	95.0	118.9	138.1	148.5	163.8	155.8	144.0	130.3	114.0	95.2	85.0
MONTHLY SURPLUS (acre-feet)	1,206.4	(16.1)	(71.0)	(90.5)	91.6	71.6	94.8	106.0	111.3	(32.8)	1,196.2	1,208.2
POTENTIAL WETLAND STORAGE (acre-feet)	300.0	283.9	212.9	122.4	214.0	285.6	300.0	300.0	300.0	267.2	300.0	300.0
Trial 4	JAN	FEB	MAT	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
TOTAL SUPPLY (acre-feet)	1,292.4	78.9	47.9	47.6	240.1	235.4	250.6	250.0	241.6	81.2	1,291.4	1,293.2
TOTAL REQUIREMENT (acre-feet)	142.6	151.6	175.5	194.7	205.1	220.4	212.4	200.6	186.9	170.6	151.8	141.6
MONTHLY SURPLUS (acre-feet)	1,149.8	(72.7)	(127.6)	(147.1)	35.0	15.0	38.2	49.4	54.7	(89.4)	1,139.6	1,151.6
POTENTIAL WETLAND STORAGE (acre-feet)	300.0	227.3	99.7	-47.4	-12.4	2.6	40.8	90.2	144.9	55.5	300.0	300.0
Trial 5	JAN	FEB	MAT	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
TOTAL SUPPLY (acre-feet)	1,292.4	100.8	91.6	91.3	283.8	279.1	294.3	293.7	285.3	103.1	1,291.4	1,293.2
TOTAL REQUIREMENT (acre-feet)	142.6	151.6	175.5	194.7	205.1	220.4	212.4	200.6	186.9	170.6	151.8	141.6
MONTHLY SURPLUS (acre-feet)	1,149.8	(50.8)	(83.9)	(103.4)	78.7	58.7	81.9	93.1	98.4	(67.5)	1,139.6	1,151.6
POTENTIAL WETLAND STORAGE (acre-feet)	300.0	249.2	165.3	61.9	140.6	199.3	281.2	300.0	300.0	232.5	300.0	300.0

Monthly infiltration losses for the Park were estimated using the method described in Section 1.3.2 of this appendix and shown for the Recommended Plan in **Table 5**. Trial infiltration rates for existing wetlands (E), new wetland (W), and new marsh areas (M) were entered in the sixth column of **Table 5** ("Infiltration rate – soil") to estimate the total monthly infiltration in acre-feet. This monthly value was then imported into **Table 7** (above) to estimate the total monthly water requirements for the Park. Trial 2 of the sensitivity analysis corresponds to the Recommended Plan and the assumed infiltration rates shown in **Table 13** (above) for Trial 2 correspond to those from **Table 5**. These rates result in a monthly infiltration loss of 20.9 acre-feet. The total monthly requirements shown in **Table 7** likewise correspond to those for Trial 2 in **Table 14** (above).

Monthly inflows of irrigation water were estimated using the method described in Section 1.4.2 of this appendix and shown in **Table 10**. The monthly values for “TOTAL SUPPLY” shown in **Table 14** (above) for Trial 2 (25-percent allocation of irrigation water) correspond to those estimated in **Table 10**.

The limited sensitivity analysis evaluated the effects of irrigation flows in 25-percent increments. The contributions to total monthly inflow of 25-, 50-, 75-, and 100-percent allocations of irrigation water are shown in **Table 15** (below). Monthly values in this table are shown in acre-feet.

Table 15 Effect of Irrigation Allocation on Project Inflow

Supply (acre-feet)	% available	WQ loading	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Irrigation Water	25%		-	22	44	44	44	44	44	44	44	22	-	-
TOTAL SUPPLY			1,292.4	78.9	47.9	47.6	240.1	235.4	250.6	250.0	241.6	81.2	1,291.4	1,293.2
Supply (acre-feet)	% available	WQ loading	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Irrigation Water	50%		-	44	87	87	87	87	87	87	87	44	-	-
TOTAL SUPPLY			1,292.4	100.8	91.6	91.3	283.8	279.1	294.3	293.7	285.3	103.1	1,291.4	1,293.2
Supply (acre-feet)	% available	WQ loading	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Irrigation Water	75%		-	66	131	131	131	131	131	131	131	66	-	-
TOTAL SUPPLY			1,292.4	122.6	135.3	135.0	327.5	322.8	338.0	337.4	329.0	124.9	1,291.4	1,293.2
Supply (acre-feet)	% available	WQ loading	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Irrigation Water	100%		-	87	175	175	175	175	175	175	175	87	-	-
TOTAL SUPPLY			1,292.4	144.5	179.0	178.7	371.2	366.5	381.7	381.1	372.7	146.8	1,291.4	1,293.2

For each trial the effects of the assumed infiltration rates and irrigation allocations on total water requirements and supply, respectively, were analyzed as shown in **Table 14** (above) to determine the monthly water surplus (or deficit) and project storage requirement to address any deficit. For example, Trial 2 from **Table 14** (above) shows that storage in the Park will be lowest in April (209.9 acre-feet) and at least 90.1 acre-feet of stored water (300 acre-feet minus 209.9 acre-feet) will be required to accommodate the cumulative deficit from February through April. This value is shown in the last column of **Table 13** (above). As discussed in Section 1.6.2, 300 acre-feet was used as a representative value for storage that could be available at the Park under the Recommended Plan. Trials shown in **Table 13** (above) with storage requirements in excess of 300 acre-feet were therefore considered in the analysis to fail.

1.7.2 Results of the Proposed Conditions Limited Sensitivity Analysis

Trials 1 and 2 of the analysis compared the difference in calculated monthly infiltration for wetland infiltration rates of $1x10^{-8}$ to $1x10^{-4}$ inches per hour. The infiltration rate for marsh areas was held constant at 0.01 inches per hour. The difference using these two infiltration rates on total monthly infiltration was found to be negligible (0.3 acre-feet each month).

Trials 3 through 7 considered the condition where the low infiltration rates from the first two trials could not be achieved. These trials evaluated infiltration rates between 0.01 and 0.03 inches per hour for both the wetlands and marsh areas. This analysis estimated that storage could be provided at the Park for an infiltration rate of 0.01 inches per hour with a 25-percent allocation of irrigation water (Trial 3), but that a 50-percent allocation of irrigation water would be required for an infiltration rate of 0.02 inches per hour (Trials 4 and 5) and that a 75-percent allocation of irrigation water would be required for an infiltration rate of 0.03 inches per hour (Trials 6 and 7).

Trials 8 through 12 examined the anticipated infiltration rates achievable using bentonite lining for the wetlands and ESS-13 treatment for the marsh areas. Trials 8 and 9 both assumed a 25-percent allocation of irrigation water and that an infiltration rate of 0.01 inches per hour could be achieved for the bentonite-lined wetland areas. Trial 8 estimated that sufficient storage could be provided at the Park if an infiltration rate of 0.02 inches per hour could be achieved for the ESS-13 treated marsh areas. Trial 9 estimated that sufficient storage could be provided at the Park if an infiltration rate of 0.03 inches per hour could be achieved for the ESS-13 treated marsh areas.

The results of Trial 10 indicated that the project could not accommodate an infiltration rate of 0.05 inches per hour for the marsh areas without sacrificing drought tolerance (i.e. the assumed allocation of irrigation water exceeded 50-percent). However, Trial 11 indicated that the project could accommodate an infiltration rate of 0.05 inches per hour for the marsh areas and remain drought tolerant if an infiltration rate of 1×10^{-4} inches per hour were achieved for the bentonite-lined wetlands.

Trial 12 evaluated whether sufficient storage could be provided at the Park if an infiltration rate of only 0.1 inches per hour were achieved for the marsh areas and determined that the required storage was much greater than could be achieved under the Recommended Plan.

1.8 References

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