Stantec

Town of Discovery Bay Community Services District

Wastewater Master Plan Update

June 5, 2019

Prepared for:

Town of Discovery Bay

Prepared by:

Stantec Consulting Services Inc.

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5.0 WASTEWATER FLOWS AND LOADS

The purpose of this section is to establish the wastewater flows and loads that comprise the foundation of this Master Plan Update. Recent historical plant influent data are evaluated together with the results of special influent monitoring studies to establish existing conditions, which are used as the basis for projecting buildout conditions in Discovery Bay.

5.1 ANALYSIS OF RECENT PLANT INFLUENT DATA

Influent wastewater flows and characteristics from January 2013 through September 2018 were received from TDBCSD and have been analyzed as described below. Graphs showing influent flows, influent BOD loads, influent BOD concentrations, and ratios of TSS and Ammonia-N concentrations to BOD concentrations for the period of study are provided. Where 30-day and 365-day average values are shown, they are centered averages based on data extending one-half the averaging period before and after the date indicated.

5.1.1 Evaluation of Historical Flows

Historical influent flows for the period of record indicated above are shown in Figure 5-1. Although there was a slight decrease in the 365-day average flow (annual average flows or AAF) for the entire period from July 2013 to March 2018 (the first and last times that centered 365-day average values were available), the actual minimum AAF may have occurred in mid-2016 and flows have been rising slightly since then. The AAF as of March 31, 2018 (includes six months before and after) was 1.32 Mgal/d.

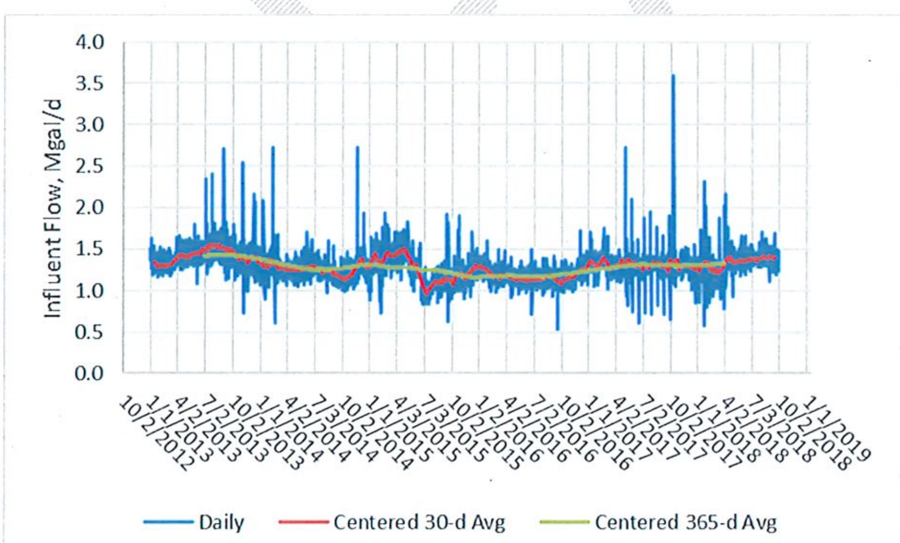

Figure 5-1 Influent Flows

Ratios of daily and 30-day average flows to then current 365-day average flows are shown in Figure 5-2. The maximum ratios shown in Figure 5-2 are compared to values adopted in the previous Master Plan in Table 5-1, which also includes recommended values for this Master Plan.

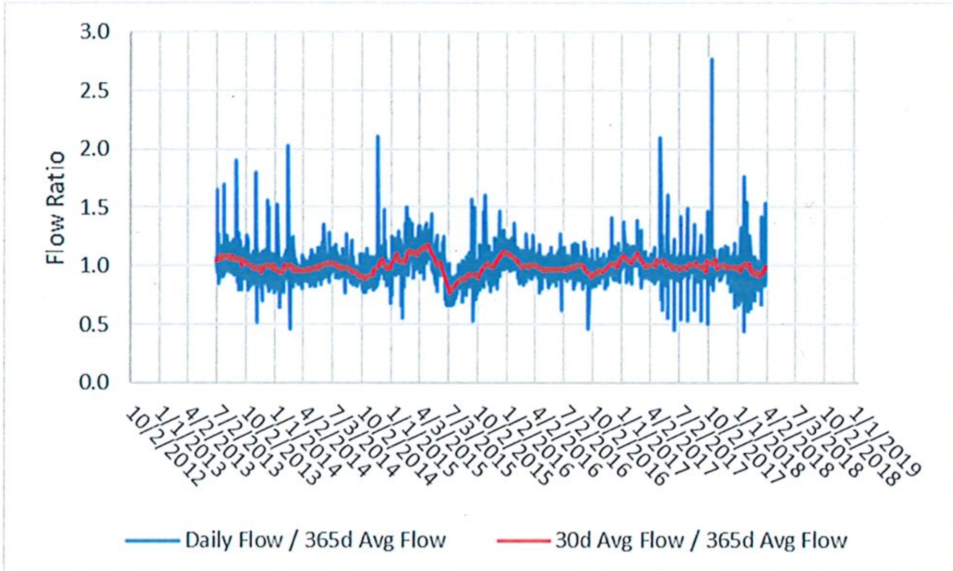

Figure 5-2 Influent Flow Ratio to Annual Average Flow

Table 5-1 Flow Ratios (Peaking Factors)

Flow Ratio	2013-2018 Data	Previous Master Plan Value	Value for This Master Plan
Max. 30d Avg / 365d Avg	1.18	1.1	1.2
Max. Daily / 365d Avg	2.10	2.0	2.1

Average dry weather flows (ADWFs) were evaluated as the average flow during the months of July through September. For the period of record considered herein the ratio of ADWF/AAF ranged from 0.87 to 1.06. For all practical purposes, the ADWF and AAF can be considered equal (the previous Master Plan ADWF/AAF ratio was determined to be 0.98).

In the Town of Discovery Bay CSD Preliminary System Evaluation and Capacity Assurance Plan (SECAP) completed by Stantec in June 2012, the peak hour flow for the collection system was determined for a 10-year frequency 6-hour storm event to be 4.35 Mgal/d. At the time, the average dry weather flow (and approximate annual average flow) was 1.59 Mgal/d, resulting in a peaking factor of 2.74. To be conservative and to allow for an increasing peaking factor with decreasing base flows, the ratio of the peak hour flow (PHF) to the AAF is established at 3.0.

5.1.2 Evaluation of Annual Average BOD Loads

Daily, 30-d average and 365-d average BOD loads are shown in Figure 5-3. Also shown in the figure is a linear regression analysis of the 365-d average data. This figure indicates an ongoing downward trend in

BOD load for the five-year period evaluated. The slope of the trendline indicates the BOD load is decreasing at the rate of about 50 lb/d per year. The apparent downward trend in BOD load is peculiar and would not be expected with continued development and while the population within the District has been increasing slightly. The BOD load data are considered to be unreliable – this topic is discussed further later in this memorandum in connection with special monitoring studies.

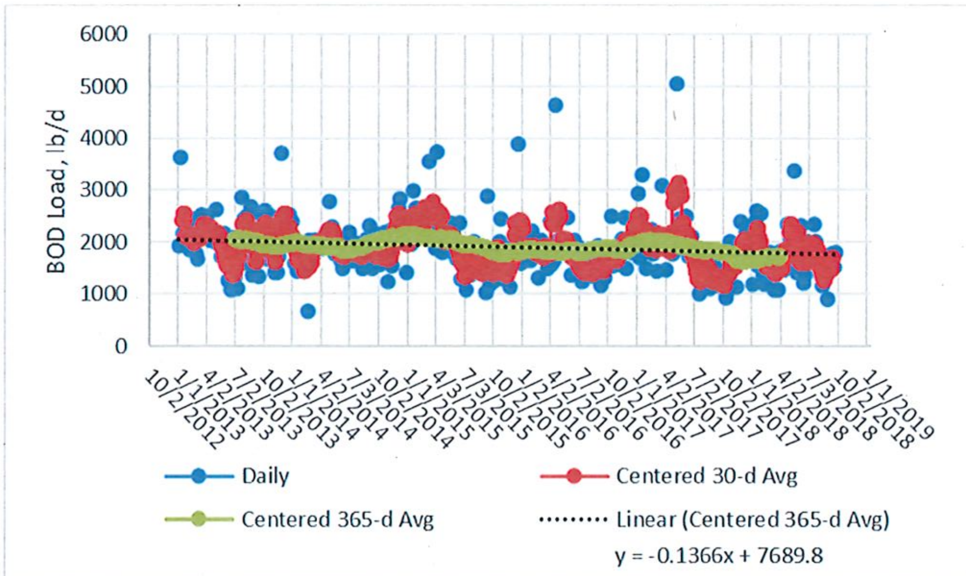

Figure 5-3 Influent BOD Loads

Ratios of daily and 30-day average BOD loads to then current 365-day average BOD loads (i.e., annual average loads, AALs) are shown in Figure 5-4. The maximum ratios shown in Figure 5-4 are compared to values adopted in the previous Master Plan in Table 5-2, which also shows recommended values for this Master Plan. As indicated in the table, the recommended values for this Master Plan are lower than the maximum values shown in Figure 5-4. Reasons for adopting the lower values are as follows:

- The historical data are based on once-per-week sampling. This is inadequate for developing reliable monthly average values, as there are only four data entries per month and a single unusual value can skew the monthly average.
- The historical BOD values are believed to be erroneous as discussed later in this section in connection with special monitoring studies.

Typical textbook peaking factor values are recommended to establish the average day maximum monthly load (ADMML) and the peak day load (PDL) for BOD. Accordingly, the following peaking factors are recommended for this Master Plan. They are the same as adopted for the previous Master Plan and for the same reasons.

- Ratio ADMML/AAL = 1.3
- Ratio PDL/AAL = 2.0

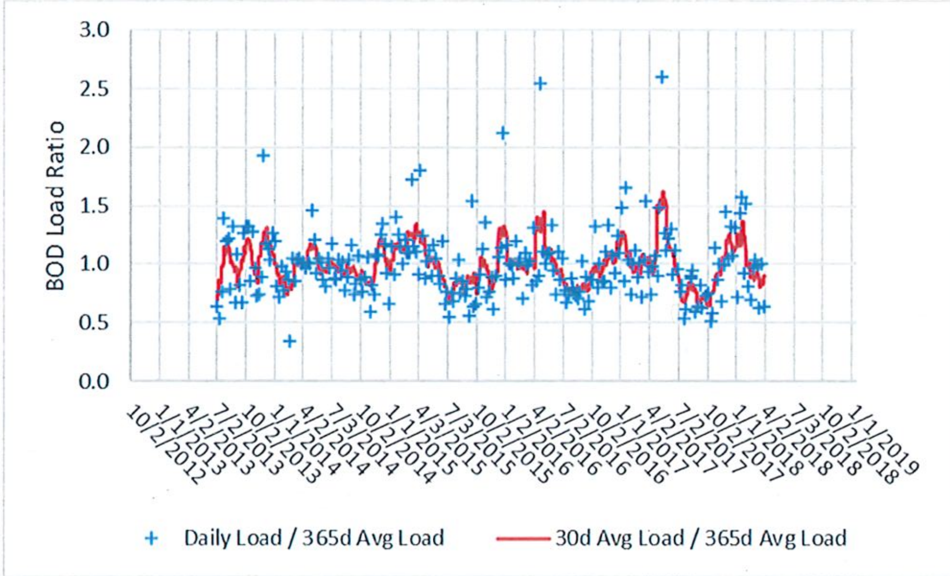

Figure 5-4 Influent BOD Load Ratios

Table 5-2 BOD Load Ratios (Peaking Factors)

BOD Load Ratio	2013-2018 Data (a)	Previous Master Plan Value	Value for This Master Plan
Max. 30d Avg / 365d Avg (ADMML/AAL)	1.6	1.3	1.3
Max. Daily / 365d Avg (PDL/AAL)	2.6	2.0	2.0

(a) Data considered to be unreliable as discussed in text.

5.1.3 Evaluation of Annual Average BOD Concentrations

Daily, 30-d average and 365-d average influent BOD concentrations are shown in Figure 5-5. From the graph, it appears that, although there is substantial scattering of data, the recorded average BOD concentration remained relatively constant for 2013 through mid-2017 and then dropped rather suddenly to a new lower tendency in the remainder of 2017 and throughout 2018. This apparent sudden decrease is peculiar. Possible explanations for the decrease could include a sudden increase in infiltration and inflow or a change in sampling or analysis methods. Although no probable cause for the decrease has been investigated, problems with the historical BOD data are discussed later in this memorandum in connection with special monitoring studies.

5.1.4 Evaluation of Influent TSS/BOD Concentration Ratios

Ratios of TSS/BOD are shown in Figure 5-6. Key observations are listed below:

1. The TSS/BOD ratio has been highly variable, which makes it difficult to have confidence in the values.

2. The central tendency of the data has been relatively constant over the five-year period evaluated. The average TSS/BOD ratio over the five-year period was 0.75, which is extremely low for domestic sewage (a value near 1.0 would be expected), which causes concern about confidence in the values.

3. Problems with historical BOD and TSS data are discussed later in this section in connection with special monitoring studies.

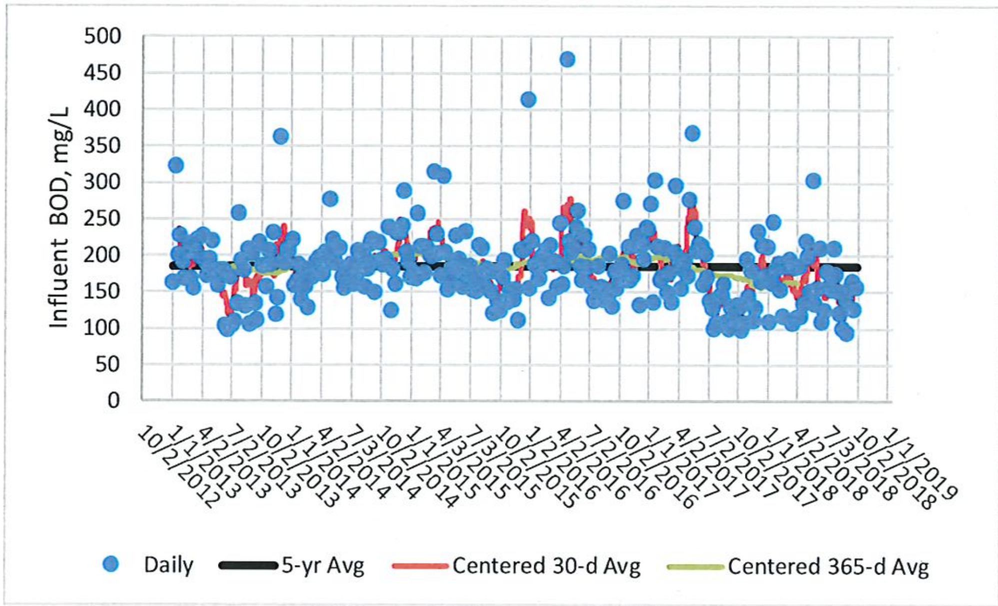

Figure 5-5 Influent BOD Concentrations

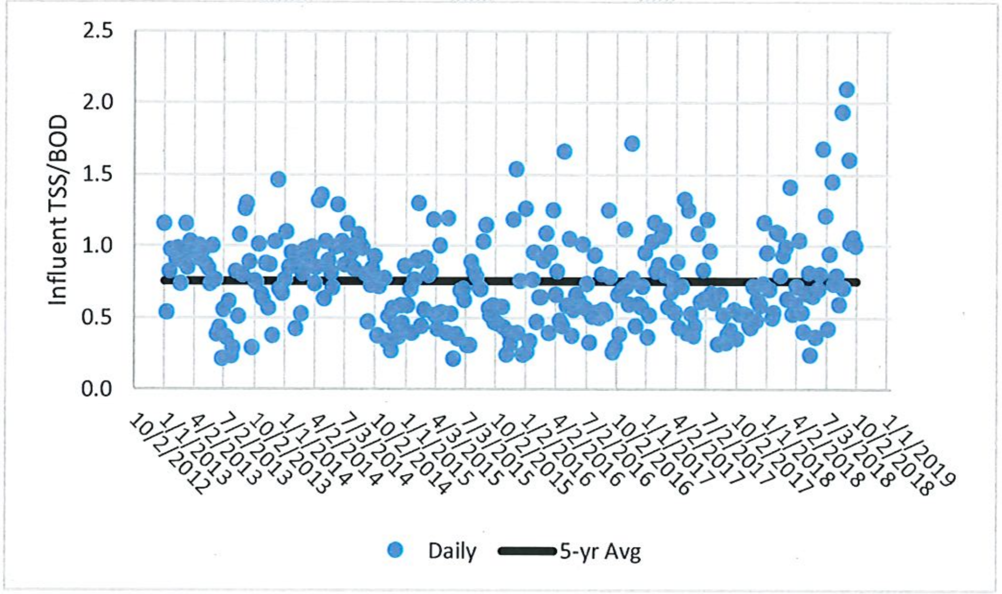

Figure 5-6 Influent TSS/BOD Ratio

5.1.5 Evaluation of Influent Ammonia-N Concentrations and Ammonia-N/BOD Concentration Ratios

Approximately two-years of influent ammonia-N concentration data were available from plant records. These data are shown graphically in Figure 5-7. As indicated in the figure, the concentrations were generally in the mid-30's at the beginning and end of the data period but were somewhat higher in the middle. The average of all the data shown is 36 mg/L.

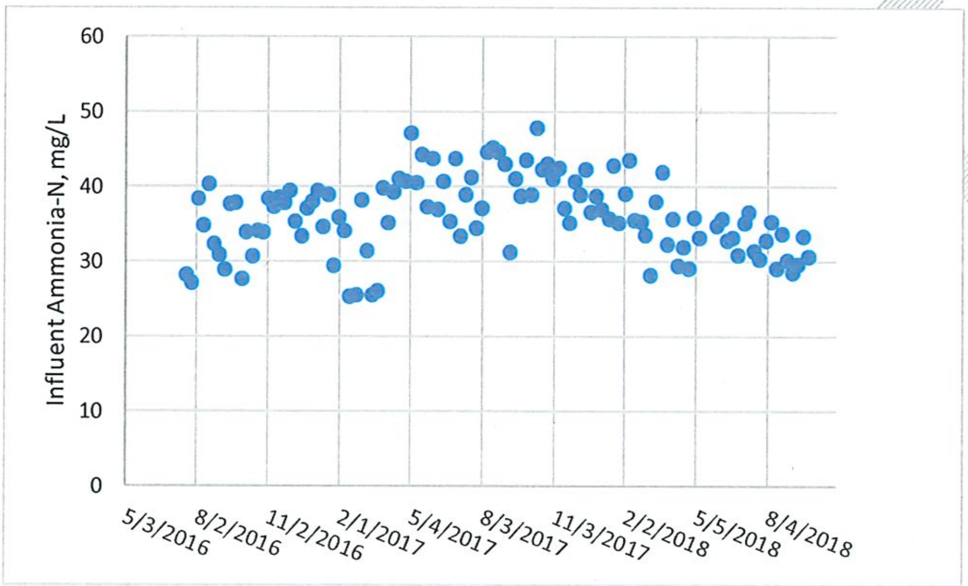

Figure 5-7 Influent Ammonia-N Concentrations

Ratios of Ammonia-N/BOD are shown in Figure 5-8. Key observations are listed below:

1. The Ammonia-N/BOD ratio has been highly variable, with values in late 2017 being substantially higher than those before and after. The reasons for such a trend are unknown, which makes it difficult to have confidence in the values.

2. The average Ammonia-N/BOD ratio for the period indicated was 0.22. This is considered to be extremely high. Normally, the influent TKN would be expected to be about 1.5 times the Ammonia-N, indicating a potential average TKN/BOD ratio near 0.33. For typical domestic wastewater, this value would be expected to be around 0.2. The apparent very high TKN/BOD ratio would adversely impact the ability of the secondary process to remove nitrogen as needed to meet the future Nitrate + Nitrite-Nitrogen limit of 10 mg/L, without supplemental carbon addition. Therefore, it is important that the TKN/BOD ratio be validated.

3. Problems with historical BOD and TSS data are discussed later in this section in connection with special monitoring studies.

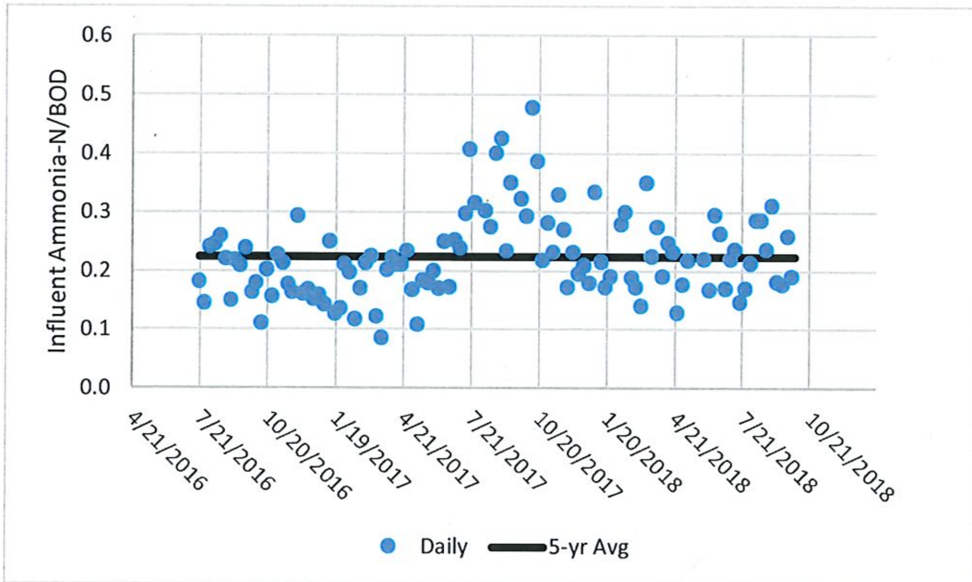

Figure 5-8 Influent Ammonia-N/BOD Ratio

5.1.6 Comparison of Recent Values to Previous Master Plan Values

A summary of recent average flows, BOD concentrations, and BOD loads for 2013 to 2018 taken from Figures 5-1 through 5-5 and the values contained in the previous Master Plan (February 2013 with updates through March 2016) is provided in Table 5-3.

When comparing April 2018 values to 2010 values from the previous Master Plan, it apparent that there have been very significant decreases in flows (1.8 to 1.33 Mgal/d) and apparent BOD loads (3002 to 1712 lb/d) in the eight years involved. Although flows can decrease due to water conservation and elimination of infiltration and inflow, BOD loads would not be expected to decrease with a stable or increasing population. As mentioned previously, problems with historical BOD data are discussed later in this section in connection with special monitoring studies.

Table 5-3 Summary of Recent and Master Plan Average Flows, BOD Load, and BOD Concentrations

	July	April	%	Exist Master Plan	
Parameter	2013	2018	Change	2010	Buildout
Annual Average Flow, Mgal/d	1.42	1.33	-6.3	1.8	2.37
Annual Average BOD Load, lb/d	2058	1712	-16.8	3002	3953
Annual Average BOD, mg/L	184	163	-11.4	200	200

5.2 SPECIAL INFLUENT MONITORING STUDIES

As presented in the previous subsection, there are several questionable attributes of the historical plant data, including the following:

1. The influent TSS/BOD ratio has been quite variable and much lower than would be expected for typical domestic wastewater (0.75 actual average versus 1.0 expected).
2. The Ammonia-N/BOD ratio has been highly variable and the implied TKN/BOD ratio is extremely high (apparent value near 0.33 versus around 0.2 expected).
3. The apparent annual average BOD load decreased 17% (2058 lb/d to 1712 lb/d) from July 2013 through April 2018. Furthermore, the April 2018 value represents a 43% decrease from the 2010 value established in the previous Master Plan (1712 lb/d compared to 3002 lb/d). A decrease in BOD load would not be expected with a stable or increasing population.

It was hypothesized that influent sampling methods could be leading to non-representative samples, thus skewing the results. In this regard, it was noted that the influent sampler intake strainer was located inside a larger perforated pipe (see Figure 5-9). Within the larger perforated pipe, quiescent conditions could be created, leading to settling and removal of solids before entering the sampler. This could lead to erroneously low results for TSS in particular, but also for BOD (and other constituents with particulate components like COD and TKN, which are discussed in subsequent paragraphs). Rag accumulations on the perforated pipe also could be causing particulates to be excluded from samples.

5.2.1 Special Influent Monitoring Study 1

To investigate the hypothesis of non-representative sampling caused by the perforated pipe shown in Figure 5-9, it was decided to conduct a special monitoring program with two independent flow proportional composite samplers. The existing "fixed sampler" would continue to be used with its sample intake inside the perforated pipe in accordance with historical practices. A second "portable sampler" would be used with its sample intake hanging freely in the flow stream (not protected inside a perforated pipe).

Daily influent samples from each of the two samplers were collected for approximately four weeks beginning in late January 2019. The constituents analyzed and the results are shown in Table 5-4. As shown in the table, the average influent TSS resulting from the portable sampler was only 70 mg/L, compared to 138 mg/L for the fixed sampler. Apparently, more solids were being excluded from the portable sampler than from the fixed sampler. However, if this was the case, then BOD and COD values should also be lower for the portable sampler as compared to the fixed sampler, but they were somewhat higher. Another perplexing factor is that ammonia-N concentrations were nearly the same or higher than TKN concentrations for both samplers. Since ammonia-N and organic-N comprise TKN, it is impossible for ammonia-N to be higher than TKN. Also, for typical domestic wastewater, the ammonia-N should be about 2/3 of the TKN.

While investigating the discrepancies, it was discovered that the portable sample intake strainer had been strapped to the outside of the perforated pipe used to protect the fixed sampler intake strainer and was not free-hanging in the flow stream. It was determined that this arrangement could cause non-representative sampling.

Because of the issues discussed above, it was determined that the results from Special Influent Monitoring Study 1 were likely unreliable. Therefore, Special Influent Monitoring Study 2 was planned.

Figure 5-9 Perforated Pipe Surrounding Sampler Intake Strainer

Table 5-4 Results from Special Influent Monitoring Study 1

		Concentration, mg/L													
		Ammonia-N		TKN		BOD		COD		TSS		VSS		FSS	
Date	Day	Fixed	Portable	Fixed	Portable	Fixed	Portable	Fixed	Portable	Fixed	Portable	Fixed	Portable	Fixed	Portable
1/21/2019	Monday	30	31	31	30	161	227	279	399	97	73	87	66	10	8
1/22/2019	Tuesday	26	27	33	31	107	181	344	556	247	103	219	87	28	16
1/23/2019	Wednesday	27	28	25		148	164	344	376	198	88	157	74	41	14
1/24/2019	Thursday	27	30	27	31	132	141	366	341	158	185	135	154	23	31
1/25/2019	Friday	26	28	36	33	211	157	551	371	239	87	156	87	73	ND
1/26/2019	Saturday	29	30	26	25	112	169	378	356	80	75	70	68	9	8
1/27/2019	Sunday	31	33	28	34	99	159	258	366	66	126	66	117	ND	9
1/28/2019	Monday	29	32	37	28	165	262	443	436	106	74	92	74	11	ND
1/29/2019	Tuesday	28	30	38	25	431	205	662	399	454	89	405	89	49	8
1/30/2019	Wednesday	26	35	35	46	144	127		394	219	77	199	71	20	7
1/31/2019	Thursday	27	38	35	33	178	174	353	424	127	79	112	72	15	7
2/1/2019	Friday	24	35	23	26	146	159	298	338	165	54	151	46	14	8
2/2/2019	Saturday	27	27	26	25	98	130	228	293	76	42	76	42	ND	ND
2/3/2019	Sunday	27	33	28	32	166	158	378	368	82	62	82	62	ND	ND
2/4/2019	Monday	29	36	28	33	178	232	403	618	101	66	101	59	ND	7
2/5/2019	Tuesday	24	30	22	24	118	141	238	323	122	58	110	50	12	8
2/6/2019	Wednesday	26	34	29	29	98	121		283	68	55	57	55	11	ND
2/7/2019	Thursday	27	37	25	34	162	193	253	373	71	43	63	43	9	ND
2/8/2019	Friday	27	35	23	31	124	123	278	298	117	48	110	42	8	7
2/9/2019	Saturday	26	35	31	36	76	122	221	309	64	41	57	41	7	ND
2/10/2019	Sunday	27	36	22	31	89	147	266	319	95	48	95	48	ND	ND
2/11/2019	Monday	26	36	24	32	129	150	311	326	114	58	104	51	10	7
2/12/2019	Tuesday	25	35	26	28	139	50	349	294	112	54	89	54	23	ND
2/13/2019	Wednesday	28	32	33	34	107	162		319	245	45	226	45	19	ND
2/14/2019	Thursday	21	31	25	34	97	108	361	478	94	68	85	58	9	10
2/15/2019	Friday	22	30	24	29	154	192	264	339	189	53	172	43	17	10
2/16/2019	Saturday	24	31	24	27	59	95	226	246	44	99	44	99	ND	ND
2/17/2019	Sunday	26	35	32	28	106	132	326	321	149	41	137	41	12	ND
2/18/2019	Monday	28	35	30	35	195	151	588	513	111	48	96	41	15	7
Sampler Weekday Avg (a		26	32	28	31	142	146	336	356	154	72	135	66	22	11
Sampler Weekend Avg (b		28	34	29	31	143	180	361	407	102	66	96	62	12	8
Sampler All Days Avg		27	33	29	31	142	156	344	372	138	70	123	65	20	10
Overall Average		30		30		149		359		104		94		15	

(a) Samples ending on Tuesday through Saturday mornings; each sample most representative of the previous day.
(b) Samples ending on Sunday and Monday mornings; each sample most representative of the previous day.

5.2.2 Special Influent Monitoring Study 2

For Special Influent Monitoring Study 2, two separate hypotheses were investigated: 1) whether the sampler intake configuration was excluding particulates in the wastewater, and 2) whether there could be issues with laboratory errors.

To address the first issue, the two samplers previously described would again be used. This time, it would be assured that the portable sampler intake strainer would be freely hanging in a well-mixed channel location away from the perforated pipe used for the fixed sampler (initially, both sampler intakes would still be in the turbulent discharge area of the Parshall flume used for influent flow measurement). To address the second issue, all samples would be sent to three different laboratories for analysis. The laboratories were FGL (the laboratory historically and routinely used), Caltest, and McCampbell.

Special Influent Monitoring Study 2 was initiated on March 28, 2019, with the first composite samples becoming available on March 29, 2019. Samples were taken daily through April 11, 2019. Unfortunately, the flow-proportional functioning of the portable sampler failed before the commencement of the study, so all portable sampler samples were timed composites throughout Special Influent Monitoring Study 2.

When the first sample was taken on Friday March 29, the portable sampler intake strainer was pulled up out of the flow stream for inspection, mainly to confirm whether the sampler intake strainer had accumulated any rags that could impair representative sampling. Unfortunately, major ragging was discovered, as shown in Figures 5-10 and 5-11. The sampler intake was cleaned and re-installed for weekend sampling. However, on Monday morning April 1, 2019, the portable sampler intake was again inspected and found to be covered with rags (see Figure 5-12). It was then clear that the sampler intake location at the discharge of the Parshall flume, which is upstream of the influent screen, would not be acceptable. Although the outside of the perforated pipe that houses the fixed sampler intake strainer could not be inspected while submerged, it is highly likely that rag accumulation is (and always has been) an issue there also.

To avoid ragging issues, it is preferable to install the influent sampler downstream from the influent screen to avoid ragging of the sampler intake. This was known and efforts were made as part of the previous Master Plan monitoring programs to install a sampler with its intake downstream of the screen. Unfortunately, the configuration of the screen channel is not suitable for sampling for two reasons: 1) the flow at this location is not turbulent and well-mixed, and 2) there is possible contamination of the sample with return activated sludge (RAS) that is introduced to the channel just downstream.

To mitigate the two issues downstream of the screen, it was decided to temporarily add concrete blocks inside the channel to create a high velocity turbulent flow that would provide good mixing and also protect against back-mixing of RAS. A photograph of the concrete blocks and sampler intake as first installed on April 1, 2019 is shown in Figure 5-13. On April 2 and 4, additional concrete blocks were added to optimize the sampler intake. The final layout is shown in Figure 5-14.

Figure 5-10 Portable Sample Intake Strainer Being Pulled Out of Flow Stream on 3-29-19

Figure 5-11 Rags Attached to Portable Sampler Intake Strainer on 3-29-19

Figure 5-12 Rags Being Removed from Portable Sampler Intake Strainer on 4-1-2019

Figure 5-13 Initial Configuration of Concrete Blocks and Sampler Intake Tube in Screen Channel on 4-1-2019

Figure 5-14 Final Configuration of Concrete Blocks and Sampler Intake Tube in Screen Channel on 4-4-2019.

5.2.2.1 Special Influent Monitoring Study 2 Results Overview

In the paragraphs below, the monitoring results are evaluated without consideration of data quality issues resulting from sample handling and timed composite sampling, which are covered in the subsequent subsection.

Tabulated results from Special Influent Monitoring Study 2 are shown in Tables 5-5 through 5-8. In the tables, the "select averages" include only data from April 3 through April 11 when the portable sampler intake was located downstream from the influent screen and believed to be free from ragging. The other data for the portable sampler is considered to be unusable. To allow comparison of the portable and fixed sampler data, select averages for the fixed sampler are also calculated.

Tables 5-5 through 5-7 present data for all of the main constituents of interest for this study, namely BOD, COD, TSS, VSS, Ammonia, and TKN. Nitrate and nitrite data are shown in Table 5-8. Although nitrate and nitrite are not expected to be present in domestic sewage, they were added to the study because, if present, they could interfere with TKN analysis. As indicated in Table 5-8, these constituents were either non-detect or at trace concentrations in all samples. No further consideration of nitrate and nitrite is included in this section.

A summary of the select average data from all three labs for both fixed and portable samplers is presented in Table 5-9. From Table 5-9, it can be noted that the concentrations of TSS and VSS from the portable sampler were approximately two times as high as those from the fixed sampler. This is considered to be clear evidence that particulates are being excluded from the fixed sampler, likely due to rag accumulation on the perforated pipe that protects the sampler intake strainer and possibly due also to solids settling inside the perforated pipe. It is further noted that BOD, COD, and TKN (TKN to a lesser extent) include both soluble and particulate components. Therefore, the concentrations of these constituents were also higher in the portable sampler than in the fixed sampler, but to a lesser extent than TSS and VSS, which are entirely particulate by definition. Ammonia results for the fixed and portable samplers were only slightly different because ammonia is soluble and not removed with particulates.

Based on the results described above, it is believed that the entire historical database of wastewater constituent concentrations, which are based on the fixed sampler, are compromised. For example, as shown in Table 5-9, the select average BOD result for the portable sampler is almost 40% higher than that for the fixed sampler (248 mg/L vs 181 mg/L). This may provide a good indication as to the general magnitude by which historical plant BOD records, which are all based on the fixed sampler location, could be skewed low. Similarly, actual influent TSS concentrations could be perhaps double those recorded.

While the likely issues associated with the fixed sampler results were not fully revealed in the previous Master Plan, it was recognized in that plan that the low values indicated in plant records for BOD and TSS were problematic and questionable. Because of this, BOD and TSS concentrations substantially higher than those indicated in plant records were adopted as the basis for the Master Plan after consideration of the District population and expected per capita BOD contributions.

Table 5-5 Special Influent Monitoring Study 2 Results – BOD and COD

Date	Comment	BOD, mg/L						COD, mg/L (a)					
		FGL		CalTest		McCampbell		FGL		CalTest		McCampbell	
		Fixed	Portable	Fixed	Portable	Fixed	Portable	Fixed	Portable	Fixed	Portable	Fixed	Portable
3/29/19	Portable Sampler at Flume, Ragged	163	184	273	380	97	250	543	366	874	1220	360	850
3/30/19	Portable Sampler at Flume, Presume Ragged	129	164	125	167	89	120	306	356	465	467	310	350
3/31/19	Portable Sampler at Flume, Presume Ragged	201	259	245	284	200	180	598	601	690	811	480	550
4/1/19	Portable Sampler at Flume, Ragged	168	214	207	245	200	210	491	506	888	891	490	570
4/2/19	Portable Sampler After Screen, Layout 1, Slight Rags	162	314	166	381	170	200	401	738	534	1030	330	550
4/3/19	Portable Sampler After Screen, Layout 2	158	285	134	268	150	160		603	553	525	160	290
4/4/19	Portable Sampler After Screen, Layout 2	169	233	127	297	150	210	384	566	616	753	380	510
4/5/19	Portable Sampler After Screen, Layout 2, No Rags	236	195	218	273	140	150	488	623	661	930	280	350
4/6/19	Portable Sampler After Screen, Layout 3	145	240			120	170	324	556			220	310
4/7/19	Portable Sampler After Screen, Layout 3	126	285	170	459	120	130	371	603	404	1270	330	530
4/8/19	Portable Sampler After Screen, Layout 3	375	186	184	294	220	280	558	461	529	1010	370	820
4/9/19	Portable Sampler After Screen, Layout 3	210	236	142	576	140	160	526	496	485	1360	320	260
4/10/19	Portable Sampler After Screen, Layout 3	328	270	231	186	180	220		571	607	506	410	420
4/11/19	Portable Sampler After Screen, Layout 3	205	234	154	301	180	140	663	671	578	831	500	540
Average		198	236	183	316	154	184	471	551	606	893	353	493
Select Average (b)		217	240	170	332	156	180	473	572	554	898	330	448
Select Avg. All Fixed		181						447					
Select Avg. All Portable		248						629					
Select Avg. Overall		214						542					

(a) Darker highlighted data for Caltest represents average of re-analysis results.
(b) Select average includes only non-ragging data from 4/3/19 to 4/11/19.

Table 5-6 Special Influent Monitoring Study 2 Results – TSS and VSS

Date	Comment	TSS, mg/L						VSS, mg/L					
		FGL		CalTest		McCampbell		FGL		CalTest		McCampbell	
		Fixed	Portable	Fixed	Portable	Fixed	Portable	Fixed	Portable	Fixed	Portable	Fixed	Portable
3/29/19	Portable Sampler at Flume, Ragged	214	63	560	543	100	394	205	63	533	513	92	364
3/30/19	Portable Sampler at Flume, Presume Ragged	62	56	55	65	53	78	55	49	50	59	48	71
3/31/19	Portable Sampler at Flume, Presume Ragged	244	241	169	198	203	208	218	221	160	189	182	192
4/1/19	Portable Sampler at Flume, Ragged	194	186	228	249	222	242	177	168	212	228	207	230
4/2/19	Portable Sampler After Screen, Layout 1, Slight Rags	187	313	160	506	182	117	163	283	156	460	164	100
4/3/19	Portable Sampler After Screen, Layout 2	74	247	158	252	97	15	74	223	145	240	80	14
4/4/19	Portable Sampler After Screen, Layout 2	83	174	63	260	113	229	83	166	58	753	104	281
4/5/19	Portable Sampler After Screen, Layout 2, No Rags	310	231	213	717	86	102	283	208	207	354	76	94
4/6/19	Portable Sampler After Screen, Layout 3	83	163			51	143	55	163			46	135
4/7/19	Portable Sampler After Screen, Layout 3	71	283	80	560	64	157	62	265	64	503	59	142
4/8/19	Portable Sampler After Screen, Layout 3	281	119	100	480	90	413	266	110	90	447	80	380
4/9/19	Portable Sampler After Screen, Layout 3	115	196	124	820	101	111	108	184	110	784	96	107
4/10/19	Portable Sampler After Screen, Layout 3	288	283	260	163	382	258	262	263	250	150	353	243
4/11/19	Portable Sampler After Screen, Layout 3	223	379	115	440	165	108	207	355	113	410	159	105
Average		174	210	176	404	136	184	158	194	165	392	125	176
Select Average (a)		170	231	139	462	128	171	156	215	130	455	117	167
Select Avg. All Fixed		146						134					
Select Avg. All Portable		281						272					
Select Avg. Overall		213						203					

(a) Select average includes only non-ragging data from 4/3/19 to 4/11/19.

Table 5-7 Special Influent Monitoring Study 2 Results – Ammonia and TKN

Date	Comment	Ammonia as N, mg/L						TKN as N, mg/L (a)					
		FGL		CalTest		McCampbell		FGL		CalTest		McCampbell	
		Fixed	Portable	Fixed	Portable	Fixed	Portable	Fixed	Portable	Fixed	Portable	Fixed	Portable
3/29/19	Portable Sampler at Flume, Ragged	31	32	29	31	28	31	35	24	77	78	39	43
3/30/19	Portable Sampler at Flume, Presume Ragged	29	26	35	31	33	30	37	23	45	41	33	32
3/31/19	Portable Sampler at Flume, Presume Ragged	32	32	34	32	33	41	31	27	93	77	35	37
4/1/19	Portable Sampler at Flume, Ragged	31	38	33	41	32	30	32	49	75	74	38	34
4/2/19	Portable Sampler After Screen, Layout 1, Slight Rags	28	25	32	34	29	33	24	42	69	90	42	36
4/3/19	Portable Sampler After Screen, Layout 2	29	35	32	40	31	41	29	35	51	61	35	39
4/4/19	Portable Sampler After Screen, Layout 2	30	37	32	41	32	40	28	47	46	59	38	42
4/5/19	Portable Sampler After Screen, Layout 2, No Rags	29	36	32	41	29	38		42	54	62	33	45
4/6/19	Portable Sampler After Screen, Layout 3	31	32			37	36	33	40			29	33
4/7/19	Portable Sampler After Screen, Layout 3	32	31	34	36	38	33	46	39	50	95	46	39
4/8/19	Portable Sampler After Screen, Layout 3	34	38	35	41	36	41	34	44	49	66	54	69
4/9/19	Portable Sampler After Screen, Layout 3	32	27	33	31	31	35	35	21	51	130	41	53
4/10/19	Portable Sampler After Screen, Layout 3	32	38	33	40	32	39	32	36	56	57	45	54
4/11/19	Portable Sampler After Screen, Layout 3	28	34	31	37	32	38	43		45	92	34	45
Average		31	33	33	37	32	36	34	36	59	76	39	43
Select Average (b)		31	34	33	38	33	38	35	38	50	78	39	47
Select Avg. All Fixed		32						41					
Select Avg. All Portable		37						54					
Select Avg. Overall		34						48					

(a) Darker highlighted data for Caltest represents average of re-analysis results.
(b) Select average includes only non-ragging data from 4/3/19 to 4/11/19.

Table 5-8 Special Influent Monitoring Study 2 Results – Nitrate and Nitrite

Date	Comment	Nitrate as N, mg/L						Nitrite as N, mg/L					
		FGL		CalTest		McCampbell		FGL		CalTest		McCampbell	
		Fixed	Portable	Fixed	Portable	Fixed	Portable	Fixed	Portable	Fixed	Portable	Fixed	Portable
3/29/19	Portable Sampler at Flume, Ragged	0.20	0	0.13	ND	0.29	ND	0.14	ND	0.31	ND	0.43	ND
3/30/19	Portable Sampler at Flume, Presume Ragged	0.07	0.02	ND	ND	ND	ND	0.08	0.02	ND	ND	ND	ND
3/31/19	Portable Sampler at Flume, Presume Ragged	0.10	ND	ND	ND	ND	ND	0.02	0.03	ND	ND	ND	ND
4/1/19	Portable Sampler at Flume, Ragged	0.09	0.07	ND	ND	ND	ND	0.02	0.02	ND	ND	ND	ND
4/2/19	Portable Sampler After Screen, Layout 1, Slight Rags	0.60	ND	ND	ND	ND	ND	0.02	0.02	ND	ND	ND	ND
4/3/19	Portable Sampler After Screen, Layout 2	ND	ND	ND	ND	ND	ND	ND	0.02	ND	ND	ND	ND
4/4/19	Portable Sampler After Screen, Layout 2	ND	ND	ND	ND	ND	ND	0.02	0.02	ND	ND	ND	ND
4/5/19	Portable Sampler After Screen, Layout 2, No Rags	0.10	ND	ND	ND	ND	ND	0.08	ND	ND	ND	ND	ND
4/6/19	Portable Sampler After Screen, Layout 3	0.09	0.10			ND	ND	0.02	0.02			ND	ND
4/7/19	Portable Sampler After Screen, Layout 3	0.10	0.10	ND	ND	ND	ND	0.02	0.02	ND	ND	ND	ND
4/8/19	Portable Sampler After Screen, Layout 3	0.10	0.08	ND	ND	ND	ND	0.02	0.02	ND	ND	ND	ND
4/9/19	Portable Sampler After Screen, Layout 3	ND	0.02	ND	ND	ND	ND	ND	0.02	ND	ND	ND	ND
4/10/19	Portable Sampler After Screen, Layout 3	ND	ND	ND	ND	ND	ND	ND	0.02	ND	ND	ND	ND
4/11/19	Portable Sampler After Screen, Layout 3	0.08	0.08	ND	ND	ND	ND	0.01	0.02	ND	ND	ND	ND

Table 5-9 Special Influent Monitoring Study 2 Results – Summary

Description	Concentration, mg/L						Concentration Ratio				
	BOD	COD	TSS	VSS	Amm.-N	TKN	COD/BOD	TSS/BOD	VSS/TSS	TKN/BOD	Amm/TKN
Select Average, Fixed Sampler, All Labs	181	447	146	134	32	41	2.46	0.80	0.92	0.23	0.78
Select Average, Portable Sampler, All Labs	248	629	281	272	37	54	2.54	1.13	0.97	0.22	0.68
Ratio Portable/Fixed	1.37	1.41	1.93	2.03	1.14	1.30	1.03	1.41	1.05	0.95	0.88

5.2.2.2 Special Influent Monitoring Study 2 Data Quality Issues

While the results from Special Influent Monitoring Study 2 are highly significant and informative with regard to issues associated with the fixed sampler and while the select portable sampler results are believed to be much more reliable than the fixed sampler results, the portable sampler results are not considered to be fully reliable as a basis upon which to base the Master Plan Update. There are several issues as noted below:

1. Only the portable sampler results from April 3 to April 11 are considered to be useful. These nine days of data, even if accurate and representative of the actual influent wastewater characteristics on those nine days, comprise only a brief snapshot of the Discovery Bay wastewater and cannot be considered to be long-term averages. Furthermore, although general comparisons between fixed and portable sampler results have been presented, these comparisons do not provide an accurate basis for adjusting historical plant records.

2. The portable sampler was operated on a timed composite basis, rather than the desired flow-proportional composite basis. With timed composite samples, sample portions taken when flows and concentrations could be low (likely in the late night and early morning hours) are given equal weighting to sample portions taken when flows and concentrations are high (likely in the middle of the day and early evening). This could lead to erroneously low constituent concentrations.

3. There were large discrepancies between the results developed by the three laboratories used for this study, indicating a likely problem of inadequate mixing during sample splitting.

Further discussion of Item 3 above is provided in the following paragraphs.

Comparisons of the analysis results from the three laboratories for the six key constituents are shown graphically in Figure 5-15, are summarized in Table 5-10, and are discussed below. Because portable sampler results are considered most relevant, only those results are shown in the figure. However, similar comparisons could be made for the fixed sampler results, which have been presented in a tabular format (Tables 5-5 through 5-7).

From the graphs shown in Figure 5-15 and from the summary data presented in Table 5-10, it can be noted that there are large discrepancies between the results obtained from each of the three laboratories. Ideally, all three labs would agree on the concentration of the same constituent in the same sample. In that case, the three data series shown in each graph would overlay each other. It is recognized that ideal is impossible and that there would be reasonable variations between the laboratories. However, the variations shown in Figure 5-15 are far more significant and troubling. Furthermore, similar to variations between fixed and portable samplers discussed previously, the variations shown in Figure 5-15 appear to be related to particulate content. For example, the variabilities in TSS and VSS, which are entirely comprised of particulate matter, are more substantial than those for BOD, which is partly soluble and partly particulate. The variability in ammonia, which is totally soluble, is the lowest. However, the variability seen in the TKN and COD data appears to be more pronounced than would be expected compared to the variability exhibited in data for BOD, TSS, and VSS (COD variability should be similar to BOD variability, while TKN variability should be lower because about 2/3 of TKN is soluble ammonia).

One possible explanation for the variability described above is that the samples may not have been adequately mixed while splitting portions out into sample bottles for shipment to each of the three laboratories. The main sample container was poured into two sample bottles for each of the three labs - one sample bottle for COD, TKN, and Ammonia, and one sample bottle for the remaining constituents - for a total of six sample bottles. Therefore, if the sample was not adequately mixed before and during sample splitting, it is possible for the COD/TKN/Ammonia sample to be impacted differently than the sample for the remaining constituents for a given lab and it is possible for the samples sent to the various labs to be impacted differently. If inadequate mixing occurred during any of the splits, then none of the three laboratory results for any of the analytes would be accurate. Results for constituents with particulate components (BOD, COD, TSS, VSS, TKN) would be skewed low in sample portions with less than average solids content, while results would be skewed high for sample portions with more than average solids content (i.e., the dregs of the sample bottle).

From the graphs shown in Figure 5-15, it can be seen that the results from FGL and McCampbell were generally in closest agreement, while those for Caltest were generally much higher. It is understood that the Caltest samples were poured last.

5.2.2.3 Special Influent Monitoring Study 2 Summary and Recommendations

Considering the data quality issues discussed above, and without the benefit of any new higher-quality data, it is difficult to determine reliable average constituent concentrations for existing conditions. However, for now, engineering judgement can be used to provide best estimates of values for use in the Master Plan. These suggested values are included in Table 5-10. The development of these values is discussed below.

<u>BOD.</u> The average BOD measured by the three laboratories ranges from 180 to 332 mg/L (average = 251 mg/L). These values could be skewed low by an unknown fraction (likely less than 10%) due to flow proportional sampling. Furthermore, the wastewater characteristics during the brief special monitoring effort do not necessarily represent average conditions.

Another estimate of the average BOD can be developed based on the District population and estimated per capita BOD load contributions, such as was done for the previous Master Plan. Based on the 2010 census and the number of new service connections added within the District since 2010, the estimated effective District population as of March 31, 2018 (the last date for which the average annual flow was calculated and shown in Figure 5-1), is approximately 15,500. Using an estimated per capita BOD load of 0.22 lb/d (from 10 States Standards for communities with in-sink grinders), the estimated total BOD load to the plant would be 3,410 lb/d. If this load occurred with the March 31, 2018 average annual flow of 1.32 Mgal/d, the BOD concentration would be 310 mg/L. Since this value is a rough estimate only and is much higher than the average value measured by the three labs (251 mg/L), the suggested value for the Master Plan is 275 mg/L (this equates to about 0.195 lb/d per person). It is reasonable to consider that the per capita BOD load for Discovery Bay could be somewhat lower than "typical" communities because many people in Discovery Bay work outside the community and contribute a portion of their daily BOD load elsewhere.

COD. The suggested average value for the COD concentration is 688 mg/L. This is based on a suggested COD/BOD ratio of 2.5, which is generally consistent with the average value determined from the three laboratories and is consistent with typical domestic wastewater (per Metcalf and Eddy/AECOM, Wastewater Engineering, Fifth Edition).

TSS. The suggested average value for TSS is based on a typical domestic wastewater TSS/BOD ratio of 1.0, which is generally consistent with the values indicated in Table 5-10. This gives an average TSS concentration of 275 mg/L.

VSS. A typical VSS/TSS ratio for domestic wastewater is around 0.80. However, the range indicated for the three labs in Table 5-10 is 0.93 to 0.99, with an average of 0.97. Tentatively, a value of 0.95 is suggested, but further evaluation of this parameter may occur during process analysis. Therefore, the initial estimated average VSS concentration is 261 mg/L.

Ammonia-N. Since ammonia is soluble, its concentration should not have been impacted by sample mixing and splitting operations. This is undoubtedly why the three laboratories were in reasonably close agreement regarding ammonia-N concentrations. Accordingly, it is appropriate to use the average value determined by the three laboratories, which is 37 mg/L. This is in close agreement with the average influent ammonia-N concentration of 36 mg/L recorded in plant records for the period from mid-2016 to mid-2018 (data shown in Figure 5-7).

TKN. For typical domestic wastewater, the ammonia-N/TKN ratio is around 0.66 (default value in BioWin process simulator). The range measured by the three laboratories and shown in Table 5-10 is 0.49 to 0.90, with an average of 0.68. This is an extremely important parameter for nitrification and denitrification design, so it is disconcerting to not have more certainty on its value. At this time, the suggested average TKN value is 55 mg/L, based on an ammonia-N/TKN ratio of 0.67. The resultant average TKN/BOD ratio is 0.20. The BioWin process simulator default value for this ratio is only 0.16, while a typical value indicated by Metcalf and Eddy/AECOM (Wastewater Engineering, Fifth Edition) is 0.18. Therefore, the suggested TKN/BOD ratio of 0.20 is somewhat higher than expected for typical domestic wastewater, but slightly lower than the average value of 0.22 measured by the three labs for this study.

The suggested average constituent concentration values indicated in Table 5-10 are believed to be reasonable current values to be used as the basis for projecting future flows and loads upon which the Master Plan will be based. However, it is highly recommended that the District proceed as soon as possible to institute permanent improvements that would allow reliable representative sampling downstream from the influent screen. Additionally, sample handling protocols should be reviewed and modified as needed. In particular, it is recommended that the large sample jug that comes from the automatic sampler be vigorously mechanically mixed while sample portions are transferred by pumping or are discharged from a spigot to be added near the bottom of the jug. Alternatively, the entire jug contents could be poured into another container better suited for mechanical mixing while withdrawing sample portions. Once the improvements and sample handling procedures are implemented, regular flow-proportional composite influent sampling should be completed on at least three days per week and samples should be analyzed for BOD, COD, TSS, VSS, Ammonia-N, and TKN until a reliable influent database can be developed. The reliable data should be used for final design of improvements.

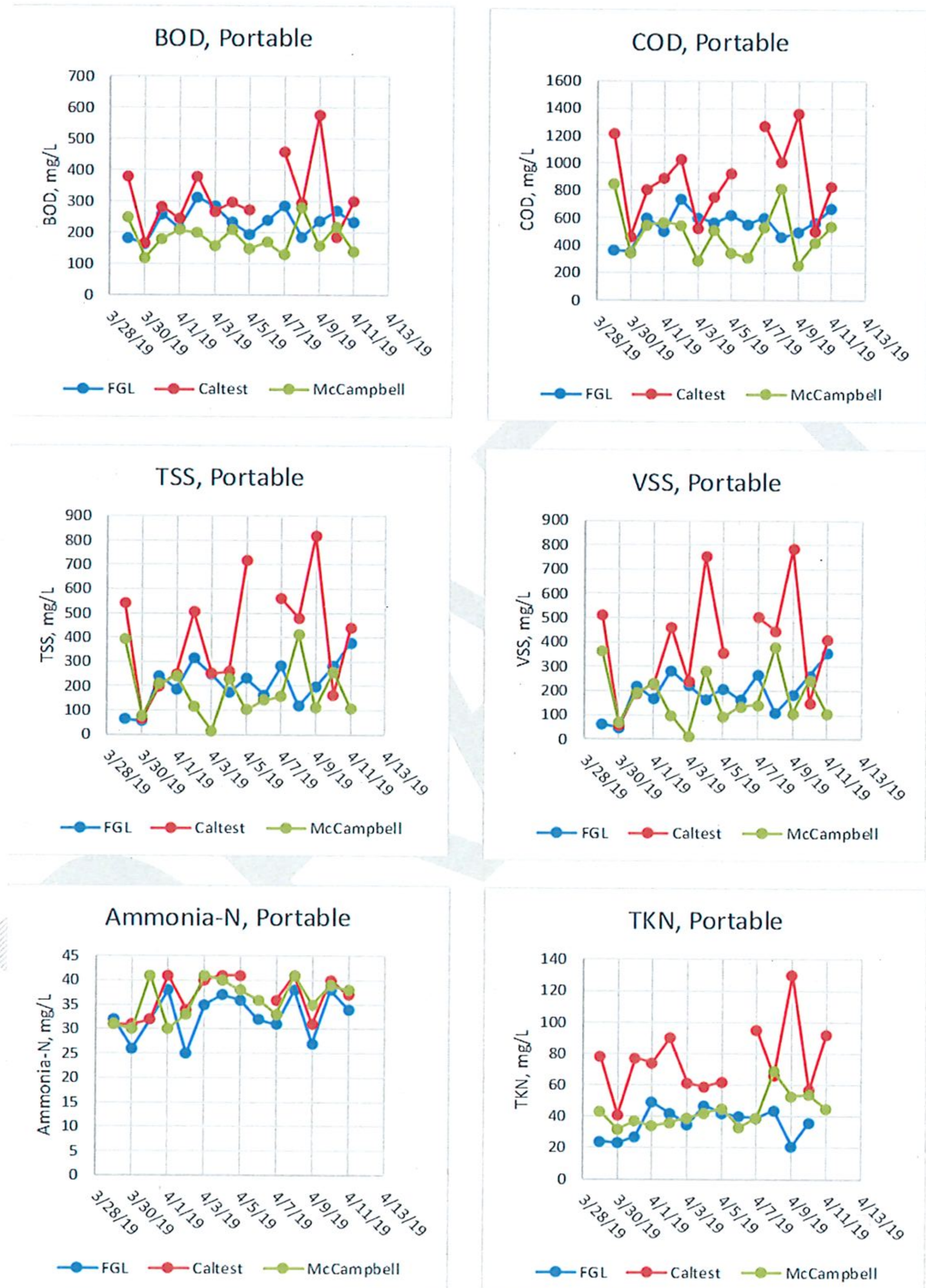

Figure 5-15 Comparison of Laboratory Results for the Six Main Constituents (Portable Sampler Only)

Table 5-10 Summary of Average Portable Sampler Constituent Concentrations and Suggested Values for Master Plan

	Concentration, mg/L						Concentration Ratio				
Description (a)	BOD	COD	TSS	VSS	Amm.-N	TKN	COD/BOD	TSS/BOD	VSS/TSS	TKN/BOD	Amm/TKN
Select Average, Portable Sampler, FGL	240	572	231	215	34	38	2.38	0.96	0.93	0.16	0.90
Select Average, Portable Sampler, McCampbell	180	448	171	167	38	47	2.49	0.95	0.98	0.26	0.81
Select Average, Portable Sampler, Caltest	332	898	462	455	38	78	2.71	1.39	0.99	0.24	0.49
Select Average, Portable Sampler, All Labs	251	639	288	279	37	54	2.55	1.15	0.97	0.22	0.68
Select Average, Portable Sampler, FGL & McC.	210	510	201	191	36	43	2.43	0.95	0.95	0.20	0.85
Suggested Value for Master Plan	275	688	275	261	37	55	2.50	1.00	0.95	0.20	0.67

(a) Select average includes only non-ragging data from 4/3/19 to 4/11/19.

The suggested average constituent concentration values indicated in Table 5-10 are approximately 38% higher than those developed for existing conditions in the previous Master Plan (e.g., BOD = 275 vs 200 mg/L and TKN = 55 vs 40 mg/L). The increased concentrations are due mostly to water conservation resulting in previously existing wastewater constituent loads being carried in less water. At the time of the previous Master Plan, the average annual flow was 1.8 Mgal/d, which is 36% higher than the current value of 1.32 Mgal/d (as of March 31, 2018). A secondary factor that has resulted in increased concentrations is that the District population has increased (resulting in higher constituent loads) even while the flows have been decreasing.

5.3 INCREMENTAL FLOWS FROM FUTURE GROWTH

Future residential and non-residential growth projections for TDBCSD are included in Section 3 and can be used as the basis of calculating incremental flows from future growth.

Flows from future residential connections can be estimated based on typical values for existing customers. Based on District records, there were 5497 equivalent primary residential households on March 31, 2018, when the annual average flow was 1.32 Mgal/d. Based on District water use records, it is estimated that approximately 98 percent of the District's sewage flow is residential, indicating an estimated annual average residential flow of approximately 1.29 Mgal/d on March 31, 2018. Therefore, the annual average sewage flow per equivalent primary residence is estimated to be 235 gpd.

Flows from future commercial and business park / office connections can be estimated using the City of Brentwood development standards of 1600 and 2000 gallons per acre per day, respectively (average annual flow).

Based on the above, incremental average annual flows from projected growth within TDBCSD are shown in Table 5-11.

Table 5-11 Average Annual Flows from Projected Growth

Development Type	Units	Number	Sewage Generation Rate, gpd/unit	Projected Flow, gpd
Residential	Homes	1208	235	283,880
Commercial	Acres	5	1,600	8,000
Business Park / Office	Acres	8.2	2,000	16,400
Total				308,280 round to 310,000

5.4 SUMMARY OF EXISTING AND FUTURE DESIGN FLOWS AND LOADS

Based on the existing flows and loads and the incremental flows from future growth established above, existing, future incremental and future total flows and loads are summarized in Table 5-12. For the Baseline Future condition shown in Table 5-12, it is presumed that per-capita flow rates will remain the same as existing ([235 gpd/home]/[2.816 people per home] = 83.5 gpd, average) and that wastewater constituent concentrations and flow and load variability for future growth will be the same as existing. An Alternate Future condition is shown based on the possibility of extreme water conservation and average per capita sewage flows decreasing to 50 gal/d. For the Alternate Future, constituent loads are assumed to be the same as the Baseline Future, resulting in much higher constituent concentrations.

Considering the discussion above, an alternative to considering plant capacity in terms of flow is to consider plant capacity is in terms of the population equivalents (PE) that can be served. Although the flows will vary with water conservation, loads will likely remain about the same. This is because a person, on average, contributes a fixed BOD load (e.g., 0.195 lb/d), regardless of how much water the person uses. Therefore, the average design BOD load of 3738 lb/d indicated in Table 5-12 represents a PE of approximately 19,000 at 0.195 lb/d per person.

In actuality, plant capacity depends both on peak flows and peak loads; therefore, neither flow nor load alone can be used to accurately represent capacity.

There are substantial plant capacity implications associated with using the Alternate Future scenario versus the Baseline Future scenario. These implications vary from process to process, depending on the extent to which the process is designed based on flow versus load and on whether the capacity is expressed on the basis of flow or on the basis of PE. For example, the oxidation ditches are sized based mostly on load (but also somewhat on flow due to their interrelationship with the clarifiers). Under the Alternate Future scenario, the load remains the same, but the flow is much lower than in the Baseline Future scenario; therefore, the oxidation ditches will have a much lower flow capacity but perhaps a slightly higher PE capacity under the Alternate Future scenario. On the other hand, pumping systems, the filters, and the UV system are designed based on flow; therefore, with decreasing flows such as in the Alternate Future scenario, the capacities of existing facilities in terms of PE would be much greater than under the Baseline Future scenario.

In general, for existing facilities or for a given set of improvements, it would be expected that the capacity of each unit process in terms of PE would be the same or higher under the Alternate Future scenario than under the Baseline Future scenario. Therefore, it should generally be conservative to base the Master Plan on the Baseline Future scenario. The number of houses and people that can be served by the plant would not be expected to decrease with water conservation. However, there might be specific instances where slight modifications in facilities and/or operations would be warranted.

Table 5-12 Existing and Future Flows and Loads

Parameter (a)	Existing (b)	Increment (c)	Baseline Future (d)	Alternate Future (e)	Previous Master Plan Future (f)
Flow Ratios					
ADWF/AAF	1.0	1.0	1.0	1.0	0.97
ADMMF/AAF	1.2	1.2	1.2	1.3	1.1
PDF/AAF	2.1	2.1	2.1	2.8	2.0
PHF/AAF	3.0	3.0	3.0	4.3	3.0
Load Ratios					
ADMML/AAL	1.3	1.3	1.3	1.3	1.3
PDL/AAL	2.0	2.0	2.0	2.0	2.0
Flow, Mgal/d					
ADWF	1.32	0.31	1.63	0.98	2.35
AAF	1.32	0.31	1.63	0.98	2.42
ADMMF	1.58	0.37	1.96	1.30	2.66
PDF	2.77	0.65	3.42	2.77	4.84
PHF	3.96	0.93	4.89	4.24	7.26
Annual Average Load, lb/d					
BOD	3,027	711	3,738	3,738	4,037
TSS	3,027	711	3,738	3,738	4,037
TKN	605	142	748	748	807
Average Day Maximum Monthly Load, lb/d					
BOD	3,936	924	4,860	4,860	5,248
TSS	3,936	924	4,860	4,860	5,248
TKN	787	185	972	972	1,050
Average Constituent Concentrations, mg/L					
BOD	275	275	275	459	200
TSS	275	275	275	459	200
TKN	55	55	55	92	40
Constituent Concentrations with ADMMF and ADMML,					
BOD	298	298	298	448	236
TSS	298	298	298	448	236
TKN	60	60	60	90	47
Constituent Concentrations with AAF and ADMML, mg/L					
BOD	358	358	358	597	260
TSS	358	358	358	597	260
TKN	72	72	72	119	52

(a) ADWF = Average Dry Weather Flow, AAF = Annual Average Flow,
ADMMF = Average Day Maximum Monthly Flow,
PDF = Peak Day Flow, PHF = Peak Hour Flow
AAL = Annual Average Load, ADMML = Average Day Maximum Monthly Load

(b) Based on AAF = 1.32 Mgal/d as of March 31, 2018.

(c) Average incremental flow from Table 5-11.

(d) Baseline future presumes per capita flows remain same as existing (83.5 gal/d, average). Flow and load peaking factors assumed same as existing.

(e) Alternate Future presumes exteme water conservation with average per capita flow of 50 gal/d. Differences between average flows and peak flows assumed same as Baseline Future. Flow peaking factors adjusted per above. Loads assumed same as Baseline Future.

(f) Final Master Plan dated February 13, 2013, Including Amendment 1.