Community Development Department
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December 14, 2022

TO: Dan Huff, City Manager
FROM: Andy Peters, Operations Supervisor

RE: 2022 Sludge Judge Results

Mr. Huff,

RESULTS
An independent Sludge Judge of Lagoon 1 and Lagoon 2 was performed on November 2, 2022 by River City Environmental 's subcontractor, Patrick Dunnegan. The Aeration Basin was not sludge judged as it has been removed from service in October 2022, solids are assumed to be the same as the previous year. The total in all lagoons as closely as we can determine is now 5896 dry tons.

DATA AND CALCULATIONS
Table 1 summarizes each sample taken, the % solids found, the geometry of the section, and totals. Previous year's findings are also summarized for comparison. During preparation of this report several math errors was identified in the 2021 report, and the 2021 total sludge number is being revised up from 4899 dry tons to 5926 dry tons. The errors are explained in the notes of Table 1.

SLUDGE JUDGE ACCURACY IN GENERAL
City Staff wishes to make any users of this information, and previous sludge judge information published by the City, aware of the inherent challenges around analytical precision (repeatability) and accuracy (closeness to true value) of Sludge Judging as a technique in general. To that end, the City's Compliance Specialist, Holly DeRamus, has provided a detailed explanation (including video demonstration by "youtube" Link) of some of these challenges in a brief Appendix. City Staff advises any users of the information to be cognizant of these inherent challenges when making decisions, especially related to year-over-year progress. The most accurate measurement of progress available is the Annual Biosolids Report. For this year the City expects to report 1461.16 Dry Tons hauled. The Annual Biosolids report is due to DEQ due in February each year.

Respectfully

Andy Peters, Public Works Div Manager
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CC: Mac Corthell, Community Development Director
Seth Kelly, Lead Operator, City of Molalla

NOTES

Definitions (Def)

1. DRY TONS: equivalent *dry short tonnage* of sludge in a section
2. GALLONS SLUDGE: gallons of sludge in a section
3. SLUDGE DEPTH: average depth of sludge measured in a section (inches)
4. ACRES: surface area (in acres), of a section
5. DENSITY: The weight of a dry gallon of sludge

Axioms (Ax):

1. There are 27,154 gallons in one acre-inch.
2. There are 2000 lbs in a short ton.
3. One acre is 43,560 square feet.
4. DENSITY is 10.842 lbs/gal (specific gravity 1.3, estimate revised from last year)

Equations (Eq):

1. GALLONS SLUDGE = SLUDGE DEPTH * ACRES * 27,154 (by Ax 1)
2. DRY TONS = (GALLONS SLUDGE * DENSITY) / 2000 (by Ax 2)

Sludge Judge 2022, Table 1

			measured depth to sludge (ft, each sample)	average depth to sludge (in)	dimensions (ft)	area (sq feet)	area (acres)	sludge (gallons)	TSS Measured (each sample)	Average TSS	Dry gallons	Short Dry Tons, Year 2022
Lagoon 1												
	Section 1											
		Subsection 1	2.5,2.9,2.0'	29.6	189x102 rectangle minus a right triangle of base/height 77x102	15,351	0.35	283,253	4.89%, 3.45% and 5.11%	4.48%	12,699	**69**
		Subsection 2	3.0', 2.9', and 2.8'	34.8	176x102 rectangle	17,952	0.41	389,438	2.33%, 2.17% and 3.11%	2.54%	9,879	**54**
		Subsection 3	2.0', 2.1',2.0'	24.4	112x102 rectangle minus right triangle of base/height 48x42	10,416	0.24	158,430	3.44%, 2.76%, 3.11%	3.10%	4,917	**27**
		Subsection 4	3.0',3.6',3.2',2.9'	47.1	195x144 rectangle	28,080	0.64	824,449	5.79%,4.98%,4.33%,6.21%	5.33%	43,923	**238**
		Subsection 5	3.1',3.8',4.0',3.79'	44.1	176x144 rectangle	25,344	0.58	696,248	1.67%,2.10%,1.43%,1.56%	1.69%	11,767	**64**
		Subsection 6	2.5',2.0',2.74'	29.0	109x144 rectangle	15,696	0.36	283,357	2.33%,3.1%,1.76%	2.40%	6,791	**37**
		Subsection 7	2.7', 2.4'	30.6	a right triangle with base/height 208x118	12,272	0.28	234,090	1.76%, 2.97%	2.37%	5,536	**30**
		Subsection 8	4.1',4.0',5.0'	52.4	176x135 rectangle	23,760	0.55	776,111	7.12%,6.33%,5.63%	6.36%	49,361	**268**
		Subsection 9	5.1', 4.3',6.2'	62.4	109x125 rectangle	13,625	0.31	529,989	2.33%, 2%, 2.46%	2.26%	11,995	**65**
	Section 2											
		Subsection 1	3.1',2.6',3.0',2.75',3.5'	35.9	rectangles 168x88 and 197x147, plus an equaliateral tirangle 109' base	49,683	1.14	1,111,236	5.73%, 4.11%, 4.78%, 3.41%,4.11%	5.12%	56,940	**309**
		Subsection 2	3.0',2.8',3.6'	37.6	rectangles 143x147 and 118x147 plus a right triangle of base/height 109x122	45,016	1.03	1,055,117	4.78%,3.46%,5.87%	4.70%	49,626	**269**
		Subsection 3	3.0',4.0',3.6',3.1'	41.1	rectangles 80x134 and 97x50, a right triangle with base/height 50x88, and an Isocelese triangle with equal sides (a)=84, and (b)=80	20,724	0.48	530,959	4.78%,5.34%,5.98%,3.21%	4.83%	25,632	**139**
	Section 3											
		Subsection 1	3.4',3.2',3.3',3.2',2.9'	38.4	a rectangle 109x260, and a right triangle with base/height 113x243	42,070	0.97	1,007,035	4.34%,7.54%,6.11%,5.11%,3.67%	5.35%	53,917	**292**
		Subsection 2	3.2',4.0',2.8',3.7',3.0'	40.1	a rectangle 260x147	38,220	0.88	954,914	6.30%,5.76%,4.78%,5.10%,3.76%	5.14%	49,083	**266**
		Subsection 3	4.0',3.3',3.0',4.1',3.6'	43.2	a rectangle 260x126	32,760	0.75	882,213	4.03%,5.49%,5.74%,6.21%,5.89%	5.47%	48,275	**262**
	Section 4											
		Subsection 1	5.8',6.7',4.9',5.0',4.6'	64.8	a rectangle 239x137	32,743	0.75	1,322,633	5.10%,6.23%,5.97%,4.20%,3.98%	5.10%	67,401	**365**
		Subsection 2	5.1',5.4',4.2'	58.8	a rectangle 239x214	51,146	1.17	1,874,714	5.23%,6.90%,3.62%	5.25%	98,422	**534**
		Subsection 3	3.0',3.7',3.0',4.1',4.0'	42.7	a rectangle 239x126	30,114	0.69	801,947	2.67%,5.79%,5.32%,3.11%,6.00%	4.58%	36,713	**199**

Lagoon 1 Total	**year 2022**	year 2021	year 2020	year 2019	year 2018
	3,485	4,183	3079	3709	6663

Lagoon 2												
	Section 1											
			2.1',1.5',1.5',1.7'	20.4	an ellipse where long radius=88' and short radius=47', a right traingle with base/height 302x428, and a rectangle 403x567	306,123	7.03	3,892,889	4.60%,3.50%,3.22%,4.00%	3.83%	149,098	**1,378**
	Section 2											
			1.5',1.0',1.3',2.0'	17.4	a rectangle 327x454 and a right triangle with base/height 327x81	161,702	3.71	1,753,918	1.60%,2.03%,2.56%,2.00%	2.05%	35,911	**332**
	Section 3											
			1.2',1.6',2.0',2.0',2.0',1.8'	21.2	a rectangle 435x259, and a right triangle with base/height 220x415	158315	3.63	2,092,203	1.67%,2.60%,1.80%,2.77%,2.33%,2.53%	2.28%	47,772	**441**

Lagoon 2 Total	**Year 2022**	Year 2021	year 2020	year 2019	year 2018
	2,151	1,483	3256	2628	207

Aeration Basin												
					a rectangle 60x90	5440	0.13				0	**0**

Permemently taken offline due to basin wall deterioration. 10/10/22

Aeration Basin Total	**Year 2022**	Year 2021	year 2020	year 2019	year 2018
	260	**260**	2.06	1.37	167

Grand Total					
	5,896	**5,926**	6337.06	6338.37	7037

Specific Gravity of Dry Ton Assumption	1.3	therefore, Density (lbs/gal) is	10.842

Notes: Year 2021 number revised UP from 4899 to 5926 due to math errors found during review of this 2022 sludge judge as follows.
Lagoon 1 section 3 subsection 2 was reported as containing 40 dry tons in 2021 due to a math error not converting Feet into Inches. Section actually contained 284.
Specific gravity of a theoretical dry ton is likely lower than 2.2 as assumed last year. We have set the assumption at 1.3 based on knowledge of process.
The thinking was that while older sludge judges assumed a specific gravity equal to water 1.0), the actual specifica gravity likely more resembles soil (2.2).
The City is unable to know the actual average specific gravity of the material since no volume measurement is possible. In the absense of further information,
a specific gravity in between these two extremes has been chosen. Further research is required to verify.
Finally, 2021 totals for Lagoon 1 were previously reported as 2111 in error, the actual column sum is 4183 after revisions to specific gravity assumptions.

Appendix

From: Andy Peters
Sent: Wednesday, December 14, 2022 4:21 PM
To: 'Holly DeRamus' <hollyllama44@gmail.com>
Cc: Seth Kelly <skelly@cityofmolalla.com>
Subject: Sludge Judge Question

Holly,

We have a question about Biosolids measurement here in Molalla: Since 2018 Molalla has trying to use Sludge Judge techniques guided by EPA 833-B-81-100 to quantify year-over-year progress in biosolids removal. However, that guidance document, in section 2.1.1, points out that doing this is difficult because of the challenges around Analytical precision (repeatability) and accuracy (closeness to true value). This being the case, has the EPA or DEQ ever been able quantify that repeatability and accuracy in analysis of Biosolids, specifically in Sludge Judging Facultative Lagoons? In other words, if I do a sludge judge of a 40 acre lagoon one year, and then another the next year, is there a +/- % accuracy I can expect, assuming those performing the tests have followed the guidance?

Thanks Holly!

Respectfully,

Andy Peters, Public Works Div Manager
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From: Holly DeRamus <hollyllama44@gmail.com>
Sent: Tuesday, January 3, 2023 11:40 AM
To: Andy Peters <apeters@cityofmolalla.com>; Seth Kelly <skelly@cityofmolalla.com>
Subject: sludge judge

Andy

To answer your question directly, no there is no definitive, accurate or reliable method of determining the repeatability or accuracy of sludge judge samples taken from a facultative lagoon. A few points to consider:

- The lagoon is a biological system that is subject to the environment and is a dynamic organism that is constantly in a state of receiving organics (food), converting the organics to water and stabilized solids all the while being in a non-static water body.

- The sludge blanket responds to temperature; in warmer weather the blanket will appear 'fluffier' as the water is less dense and in colder weather the blanket will appear more defined as the water is colder and more dense. Temperature also affects the biological activity in the sludge blanket, as the water warms the blanket appears fluffier and in colder temperatures the blanket becomes denser as biological activity is slowed. Suffice it to say to compare blanket sludge judge readings the readings must be taken at the same time of the year and the same water temperature.

- The sludge judge itself is a tool for operators to use to get a general idea of sludge levels in clarifiers and can also be used in lagoon systems for a gross general measure of sludge levels. A sludge judge takes a core sample of the entire water column and gives the operator a visual view of the sludge blanket. There is a good video of the use of a sludge judge and just how readings can be misleading. Please note that all sludge judge readings in the lagoon are preformed from a boat on the lagoon. https://youtu.be/fYyoRJwbq6Q

- The video also demonstrates the last piece of the puzzle which is the sample collection for solids calculation. As the sludge judge takes a core sample of the entire water column, getting a sample of just the blanket is nearly impossible as demonstrated as the sludge just is emptied in a rush of water. All the calculations as to content of the lagoon are based on these samples and numbers. The sludge judge is a good tool for a visual inventory of sludge levels.

- The most accurate measure of sludge removed is from the sludge that is actually removed from the lagoon in gallons and concentration. As there is no good way to get a 'before' number it becomes problematic to determine percent removals. The volume of sludge removed to date has been significant and has met the intent of improving the operability of the existing system as it moves to decommission.

- The final piece is continued plant operation during the sunsetting of the lagoon system. Given the aeration basin situation the primary lagoon must be operated in a manner to meet permit limits going forward. For optimum operation of the primary lagoon the sludge dredging should be curtailed to allow the organics entering the lagoon to settle and begin to digest in the bottom of the lagoon. This will reduce the organic loading to the second lagoon and allow the conversion process to reduce effluent BOD, Suspended Solids and ammonia.

    - The other immediate concern is the loss of the aeration basin and the need for additional oxygen to the primary lagoon for the duration of the operation. Previous calculations suggested a horsepower requirement of 75 hp to aid in the conversion of BOD and reduction of ammonia. This aeration should be as close to the inlet end of the lagoon as possible.

I look forward to working with you going forward.

Holly DeRamus