EVALUATION OF ODOR EMISSIONS AND THEIR CONTROL AT THE BRATTLEBORO WASTEWATER TREATMENT FACILITY

Prepared for:

TOWN OF BRATTLEBORO PUBLIC WORKS
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January, 2019

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EXECUTIVE SUMMARY

The Town of Brattleboro, Vermont owns and operates a three million gallon per day (mgd) wastewater treatment facility (WWTF) that was upgraded and expanded in 2013. The plant was designed and constructed with a novel, two-phase sludge digestion process to achieve Class A biosolids. Unfortunately, the process was difficult to control due to mechanical and software problems, and when operated, produced foul odors that were detectable a mile away in downtown Brattleboro. This process is no longer in use. Although odor complaints have dropped dramatically since modifying the sludge digestion process, the Town still receives some complaints attributable to the wastewater treatment plant.

In August of 2018, Bowker & Associates, a firm specializing in the assessment and control of odors from wastewater facilities, was retained by the Town to 1) implement an inventory of odor emissions from the facility, 2) conduct odor dispersion modeling to identify and prioritize the success of odor, and 3) evaluate appropriate odor control options for those sources potentially impacting the community.

DESCRIPTION OF FACILITIES

The Brattleboro WWTF is a secondary wastewater treatment plant with an average design flow of 3.0 mgd and a peak hourly flow of 9.75 mgd. The unit wastewater treatment processes consist of influent screening and grit removal (headworks), influent pumping, primary clarification, biological treatment with Rotating Biological Contactors (RBC's) and Moving Bed Bioreactor (MBBR), final clarification, and disinfection. At the time of the sampling, the MBBR was not in operation. Settled solids from the final clarifiers are returned back to the primary clarifiers for co-settling. The facility accepts and treats a significant volume of septic tank waste (septage).

The plant was designed with a novel, proprietary sludge digestion process known as Two-Phase Anaerobic Digestion (2PAD), but this process is not in use. Currently, two anaerobic digesters are operated in the mesophilic mode. Settled sludge from the primary clarifiers is sent directly to the mesophilic anaerobic digesters for stabilization. After digestion, the biosolids are pumped to a large open storage tank. Biosolids are then dewatered using rotary presses, and the resulting cake deposited into trailers in the truck bay. The dewatered biosolids are trucked off-site by an outside contractor.

SAMPLING PROGRAM

A sampling program was implemented for the purpose of 1) characterizing the wastewater entering the Brattleboro WWTF, and 2) measuring the odor emissions from the various sources of odor at the plant. This involved sampling of both the wastewater and odorous air in order to provide a full characterization of any problem areas.

The liquid-phase sampling program consisted of collecting samples of the wastewater and measuring total sulfide, pH, oxidation-reduction potential (ORP), and temperature. Wastewater samples were collected from the influent wastewater and primary clarifier effluent.

The air sampling program consisted of 1) collecting air samples to measure the strength of the odor in dilutions to threshold, 2) collecting selected air samples to measure the concentration of odorous reduced sulfur compounds, and 3) measuring hydrogen sulfide concentrations in the field with a portable instrument.

Dispersion modeling was used to predict the impact of the Brattleboro WWTF odor emissions on surrounding neighborhoods. The EPA-recommended AERMOD computer model analyzed a full year of meteorological conditions and selected those worst-case conditions that produced the highest off-site odor level. The worst-case conditions are usually associated with low wind speeds and temperature inversions, i.e. a "stable" atmosphere with little mixing and dispersion. Such conditions often occur during early morning or evening hours.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. The open storage tank for anaerobically digested sludge is the largest source of odors at the Brattleboro WWTF, accounting for almost half of the total plant odor emissions.

2. The primary clarifier accounts for about 25 percent of the total plant odor emissions.

3. The exhaust from the dewatering room accounts for 15 to 20 percent of total odor emissions, but this only occurs during dewatering operations.

4. The headworks and truck loading bay are not significant contributors to plant odors.

5. The activated carbon media in the headworks odor control system is exhausted.

6. The influent wastewater is relatively "fresh" with no sulfide.

7. The plant receives large volumes of odorous septic tank waste (septage), which is likely increasing the odor potential of the primary clarifier.

8. Although there is little or no sulfide in the influent wastewater, concentrations in the primary effluent were 0.3 to 0.4 mg/L, indicating that sulfide generation is occurring in the primary clarifier.

9. The practice of returning secondary sludge back to the primary clarifier for co-settling likely increases sulfide generation.

10. Chemical addition to the digested sludge storage tank is unlikely to be effective for odor control and could affect sludge dewaterability.

11. Addition of a liquid calcium nitrate product to the influent wastewater by the Town may have had a limited effect on H_2S concentrations in the RBC splitter box, but the impact of higher doses should be investigated.

Recommendations

1. Install a flat, aluminum cover over the digested sludge storage tank to contain odors. The order-of-magnitude opinion of probable capital cost is $177,600.

2. Maintain access to mixer for maintenance; relocate motor as required by NFPA-820.

3. Passively vent storage tank headspace to atmosphere without treatment.

4. Conduct additional monitoring of vent emissions as necessary.

5. Evaluate operational and chemical strategies to reduce odor emissions from the primary clarifier.

6. Use datalogging H_2S analyzer at RBC splitter box to document improvements to primary clarifier emissions.

7. Replace media in headworks odor control system with high-H_2S capacity activated carbon.

1. INTRODUCTION

The Town of Brattleboro, Vermont owns and operates a three million gallon per day (mgd) wastewater treatment facility (WWTF) that was upgraded and expanded in 2013. The plant was designed and constructed with a novel, two-phase sludge digestion process to achieve Class A biosolids. Unfortunately, the process was difficult to control due to mechanical and software problems, and when operated, produced foul odors that were detectable a mile away in downtown Brattleboro. This process is no longer in use. Although odor complaints have dropped dramatically since modifying the sludge digestion process, the Town still receives some complaints attributable to the wastewater treatment plant.

In August of 2018, Bowker & Associates, a firm specializing in the assessment and control of odors from wastewater facilities, was retained by the Town to 1) implement an inventory of odor emissions from the facility, 2) conduct odor dispersion modeling to identify and prioritize the success of odor, and 3) evaluate appropriate odor control options for those sources potentially impacting the community.

2. DESCRIPTION OF FACILITIES

The Brattleboro WWTF is a secondary wastewater treatment plant with an average design flow of 3.0 mgd and a peak hourly flow of 9.75 mgd. The unit wastewater treatment processes consist of influent screening and grit removal (headworks), influent pumping, primary clarification, biological treatment with Rotating Biological Contactors (RBC's) and Moving Bed Bioreactor (MBBR), final clarification, and disinfection. At the time of the sampling, the MBBR was not in operation. Settled solids from the final clarifiers are returned back to the primary clarifiers for co-settling. The facility accepts and treats a significant volume of septic tank waste (septage). In June, July, and August of 2018, an average of 8,200 gallons per day (gpd) of septage was treated.

The plant was designed with a novel, proprietary sludge digestion process known as Two-Phase Anaerobic Digestion (2PAD). The first phase is a high temperature (thermophilic) anaerobic process, followed by conventional mesophilic anaerobic digestion. Experience has shown that, unless operated in a very narrow range of temperatures, thermophilic anaerobic digestion can generate foul odors not typically associated with the lower temperature (mesophilic) digestion process. Currently, two anaerobic digesters are operated in the mesophilic mode. Settled sludge from the primary clarifiers is sent directly to the mesophilic anaerobic digesters for stabilization. After digestion, the biosolids are pumped to a large open storage tank. Biosolids are then dewatered using rotary presses, and the resulting cake deposited into trailers in the truck bay. The dewatered biosolids are trucked off-site by an outside contractor.

Figure 1 shows an aerial view of the Brattleboro WWTF. South of the plant, the land area is generally comprised of industrial facilities, some of which are abandoned. The nearest residences, however, are only 1,000 ft. to the northeast and 1,500 ft. to the southwest of the plant. The plant's location in the Connecticut River valley can cause odors to be "trapped" under certain meteorological conditions.

3. SAMPLING PROGRAM

3.1 Methodology

A sampling program was implemented for the purpose of 1) characterizing the wastewater entering the Brattleboro WWTF, and 2) measuring the odor emissions from the various sources of odor at the plant. This involved sampling of both the wastewater and odorous air in order to provide a full characterization of any problem areas.

The sampling program for the wastewater consisted of 1) collecting samples of the wastewater and measuring total sulfide, pH, oxidation-reduction potential (ORP), and temperature. Wastewater samples were collected from the influent wastewater and primary clarifier effluent. Wastewater pH, temperature, and ORP were measured in the field using a Myron L Model 3P analyzer. Total sulfide was measured in the field using a Chemetrics sulfide test kit with a range of 0.1 to 10 mg/L.

An air sampling program was implemented to characterize and quantify the odorous emissions from the Brattleboro wastewater treatment plant. This consisted of 1) collecting air samples to measure the strength of the odor in dilutions to threshold, 2) collecting selected air samples to measure the concentration of odorous reduced sulfur compounds, and 3) measuring hydrogen sulfide concentrations in the field with a portable instrument.

Samples of air from point sources such as stacks or exhaust vents were collected in 10 liter (L) and 3 L Tedlar bags using an SKC, Inc. vacuum chamber and sampling pump. When a vacuum is applied to the chamber containing the sample bag, odorous air from the source is conveyed through Teflon tubing directly into the sample bag, eliminating possible contamination by the pump. The sample bags were filled to "condition" the bags, the air expelled, and then refilled again in accordance with standard industry procedures.

For area sources such as the primary clarifiers and biosolids storage tank, a "flux chamber" was used to isolate the surface. The flux chamber has a flotation collar for open water surfaces. For sources with no input of air (anoxic zone of oxidation ditch), air flow through the flux chamber is induced by introducing 3 liters per minute of odor-free air, allowing the chamber to reach equilibrium, and then collecting a sample. Figure 2 shows a diagram of the flux chamber system.

FIGURE 1. AERIAL VIEW OF BRATTLEBORO WASTEWATER TREATMENT FACILITY

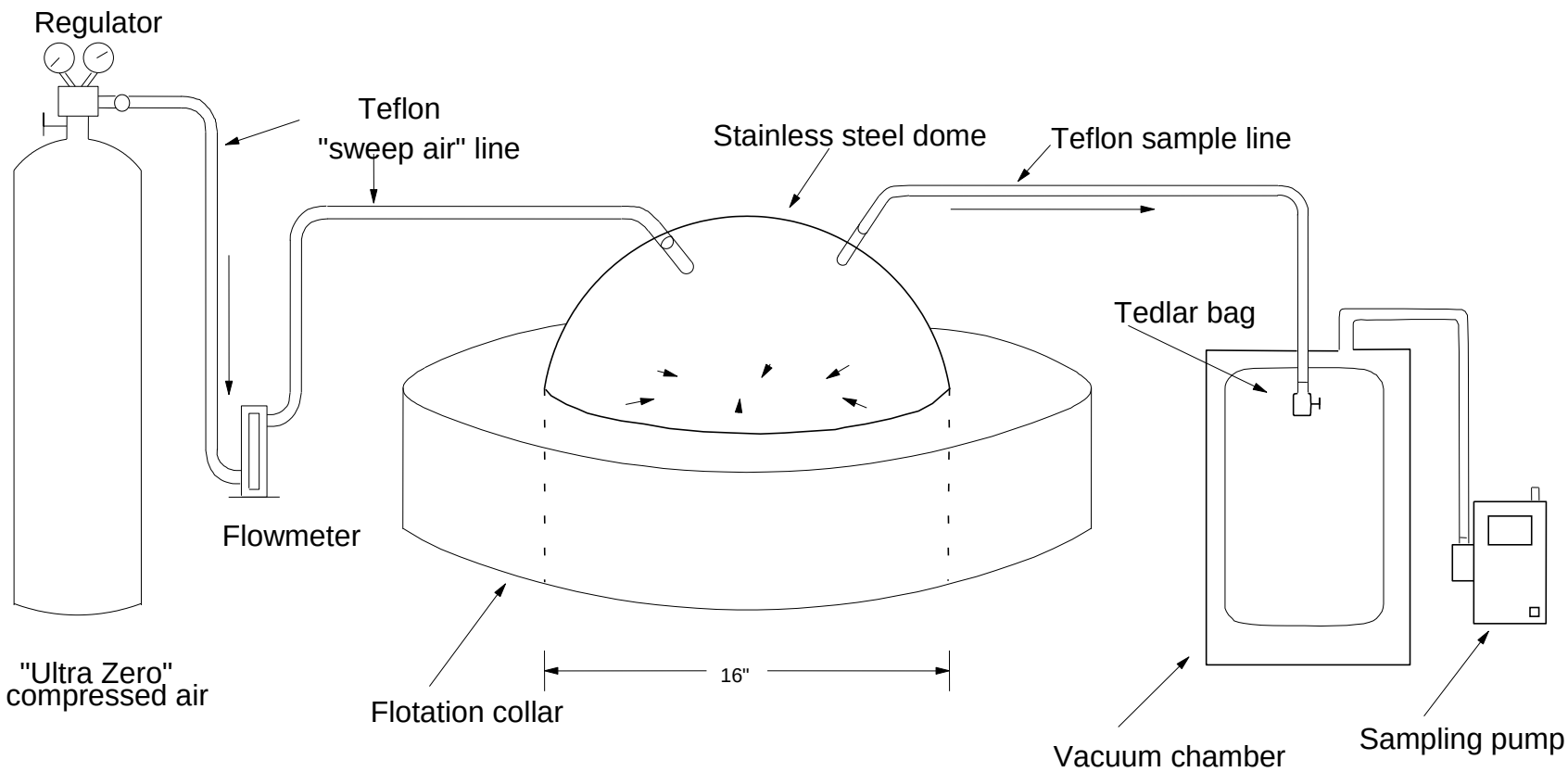


FIGURE 2. DIAGRAM OF FLUX CHAMBER SAMPLING SYSTEM

The 10 L air samples were sent by overnight carrier to St. Croix Sensory in Stillwater, MN for determination of odor concentration in accordance with ASTM E-679 as well as the European CEN standard. This test measures the number of dilutions of odor-free air required before half of a 6-member trained odor panel can no longer detect the odor. The resulting number is referred to as the dilution-to-threshold ratio (D/T) or odor "concentration."

The 3 L Tedlar bags collected from selected samples were shipped to Mayfly Laboratories in Mystic, CT for determination of reduced sulfur compounds via GC-FPD. This analysis measures the concentration of up to 20 odor-causing sulfur compounds, many having an odor detection threshold of 1 ppb or less. In addition, hydrogen sulfide levels we4re measured in the field during sampling using an Interscan Model 4170 H_2S analyzer with a range of 0.1 to 200 ppm.

Air samples were collected and analyzed from the following locations:

1. Headworks building exhaust
2. Inlet and outlet of headworks odor control system
3. Primary clarifier settling zone
4. Primary clarifier effluent channel
5. Digested sludge storage tank
6. Dewatering room exhaust
7. Truck bay exhaust

In addition, datalogging H_2S analyzers (OdaLogs) were suspended 1) in the influent channel of the headworks and 2) in the splitter box to the RBC's. These devices remained in place for 3 to 7 days, recording the H_2S concentration every minute.

3.2 Results

3.2.1 Wastewater Conditions

Table 1 shows the results of analyses conducted on the influent wastewater and primary clarifier effluent. In general, the influent wastewater is relatively "fresh"; that is, the oxidation-reduction potential (ORP) is typically above -100 millivolts (mV), indicating that the wastewater has not become fully anaerobic. This is supported by the fact that sulfide concentrations were consistently below detection limits (<0.1 mg/L). Sulfide is produced under anaerobic conditions.

Samples were collected from the primary effluent (before the weirs) on the second day, as hydrogen sulfide was detected in the air on the first day of sampling. These wastewater samples revealed 1) lower ORP levels conducive to sulfide generation, 2) measurable levels (0.3 to 0.4 mg/L) of sulfide, and 3) lower pH of 6.5 to 6.9 that favors the release of hydrogen sulfide gas.

TABLE 1 RESULTS OF LIQUID STREAM SAMPLING Brattleboro WWTF						
Location	**Time**	**pH, s.u.**	**ORP, mV**	**Temp, °C**	**Total Sulfide mg/L**	**Comments**
	8/28/18					
Influent	7:30 AM	7.0	-60	20.8	0	
Influent	9:00	7.2	-110	21.2	0	
Influent	11:30	7.1	-130	23.1	0	
Influent	1:00 PM	7.0	-100	23.5	0	
	8/29/18					
Influent	7:45 AM	6.9	+50	21.2	0	
Primary effluent	8:00	6.5	-130	21.7	0.3	
Influent	9:00	7.2	+10	21.7	0	
Primary effluent	9:10	6.7	-170	22.4	0.3	
Influent	11:10	7.1	-110	22.7	0	
Primary effluent	11:20	6.8	-190	23.9	0.4	
Influent	1:00 PM	7.3	+5	23.3	0	
Primary effluent	1:10	6.9	-190	25.7	0.3	

Figure 3 shows the levels of hydrogen gas (H_2S) in the headspace of the influent channel. Note that concentrations were consistently near zero except for occasional spikes associated with septage deliveries. These spikes ranged from about 5 ppm of over 60 ppm H_2S. Figure 4 shows the H_2S concentrations in the splitter box to the RBC's. This structure receives the effluent from the primary clarifiers and, when in operation, effluent from the MBBR. Here, hydrogen sulfide was present in concentrations ranging from 0 to 79 ppm, and averaging 9 ppm.

The elevated levels of H_2S at the splitter box compared to the influent channel, as well as the presence of sulfide in the primary effluent (vs. none in the influent), suggests that hydrogen sulfide is being generated in the primary clarifier. This may be due to the wastewater's detention time in the primary clarifier, the return of secondary sludge to the clarifier, and the presence of septage solids. It is generally believed that the return of secondary sludge for co-settling in the primary clarifier promotes anaerobic conditions and sulfide generation, since the active biomass in the secondary sludge quickly depletes any dissolved oxygen in the primary clarifier.

3.2.2 Air Sampling

Table 2 shows the results of the odor emissions inventory at the Brattleboro WWTF. The results are discussed by source, beginning at the headworks.

<u>Headworks</u>

The headworks roof exhaust (Sample 1) had an odor concentration of 1,200 dilutions to threshold (D/T) and an H_2S concentration of 0.2 ppm. These are relatively low levels of both odor and H_2S. At the time, the roof-mounted air handler was not operational and the exhaust fan was being operated at a low speed, with air flow rate estimated at 300 cfm.

The odor control system serving the channels and wet wells of the headworks showed an odor removal efficiency of only 61 percent (Samples 2 and 3). Although the activated carbon is still removing some of the reduced sulfur compounds as shown in Table 2, efficiency is poor, and "breakthrough" is occurring.

<u>Primary clarifier</u>

Samples from the quiescent setting zone of the primary clarifier showed moderately high odor levels of 6,900 and 5,200 D/T and hydrogen sulfide concentrations of 1.0 and 1.5 ppm (Samples 6 and 9). The effluent channel of the primary clarifier had much higher odor concentrations of 55,000 D/T and >60,000 D/T, and H_2S concentrations were 16.1 ppm (Samples 7 and 10). In addition to H_2S, there were significant levels of other odorous sulfur compounds such as methyl

FIGURE 3. H_2S vs. TIME – INFLUENT CHANNEL
Brattleboro WWTF

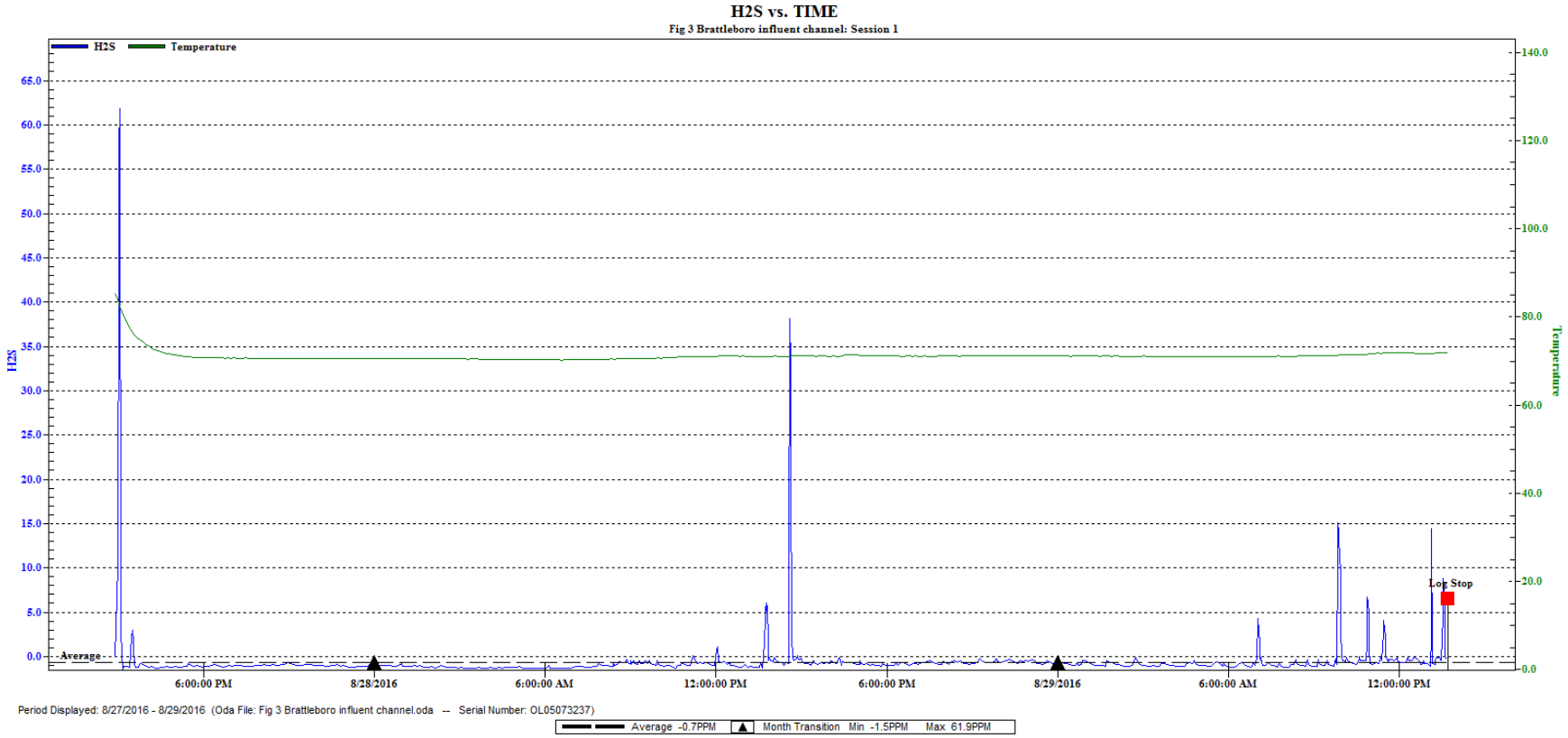


FIGURE 4. H_2S vs. TIME – RBC SPLITTER BOX;
Brattleboro WWTF

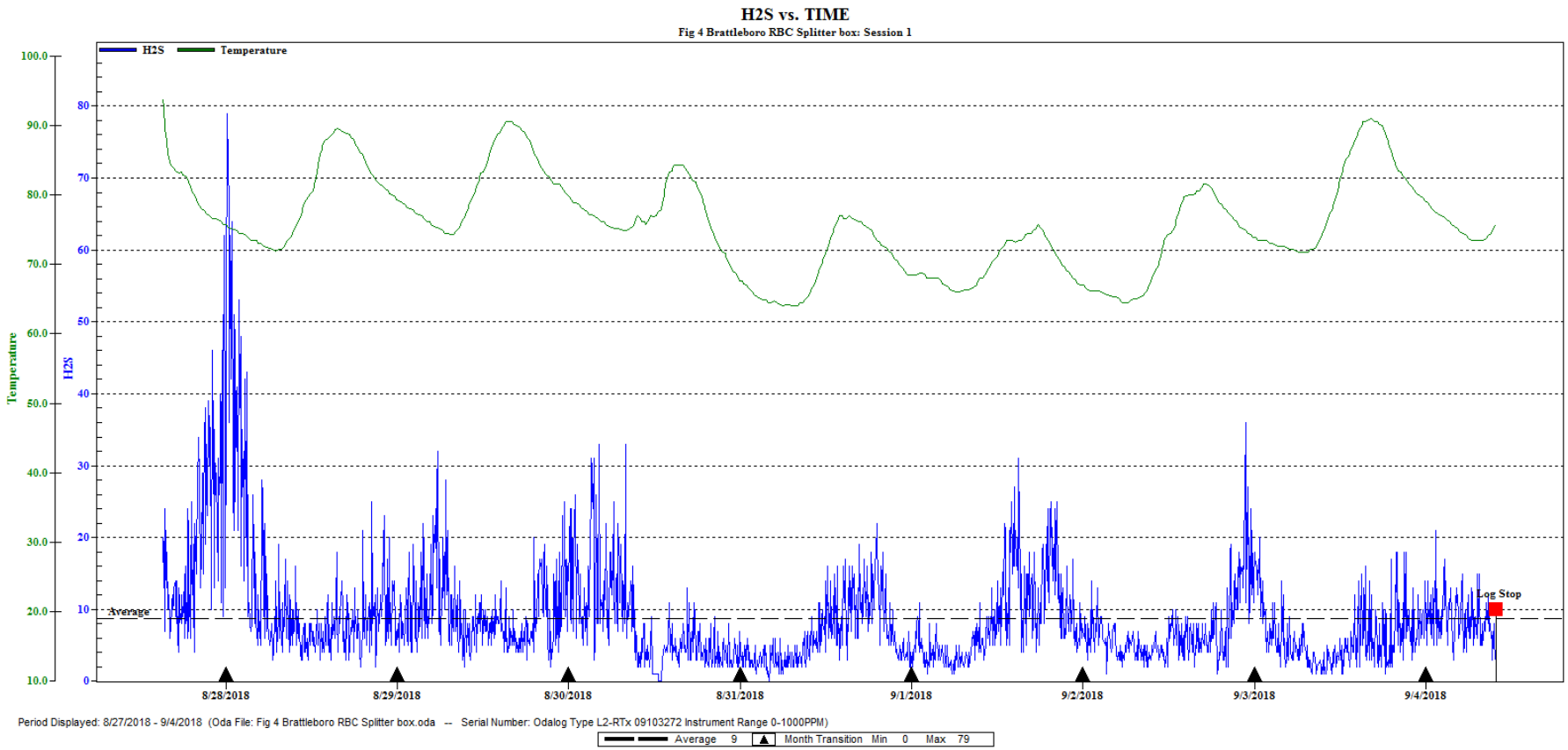


TABLE 2
SUMMARY OF AIR SAMPLING DATA;
Brattleboro WWTF

Location	Time	Odor Conc'n, D/T	Field H_2S, ppm	Reduced Sulfur Compounds[1], ppb						
				H_2S	COS	MM	DMS	CS_2	DMDS	DMTS
	8/28/18									
1. Headworks roof exhaust	8:20 AM	1,200	0.2							
2. Inlet of headworks carbon unit	8:40	6,900	2.6	505	263	63	100	37	682	159
3. Outlet of headworks carbon unit	8:55	2,700	0.3	<5	102	11	78	42	84	58
4. Truck bay exhaust-doors open	9:35	530	0.0							
5. Press room exhaust	9:45	3,900	1.0							
6. Primary clarifier surface	10:35	6,900	1.0							
7. Primary clarifier effluent channel	11:00	55,000	16.1	5,583	168	53	359	15	1,483	642
8. Sludge storage tank surface	11:45	>60,000	66	32,238	15	14	23	105	7.3	0.6
	8/29/18									
9. Primary clarifier surface	9:45 AM	5,200	1.5							
10. Primary clarifier effluent channel	10:15	>60,000	16.1	4,266	69	294	211	88	99	20
11. Truck bay exhaust – doors closed	10:45	1,300	0.3							
12. Sludge storage tank surface	11:30	>60,000	67	32,978	139	472	270	350	55	5.9

mercaptan and dimethyl disulfide. These compounds are typically produced under anaerobic or anoxic conditions, and have a disagreeable "rotten vegetable" or "rotten cabbage" character.

Digested sludge storage tank

Air samples were collected from the surface of the open storage tank containing anaerobically-digested sludge (biosolids). Hydrogen sulfide levels, as measured in the field, were very high at 66 and 67 ppm, and odor concentrations were reported as >60,000 D/T (Samples 8 and 12). Reduced sulfur compounds were also present at significant levels, particularly methyl mercaptan and dimethyl sulfide, which have detection thresholds below 1 part per billion (ppb). The odor from the digested sludge storage tank was quite strong, and was detectable on several occasions on the plant grounds during the two days of sampling. Although reported as >60,000 D/T, the actual odor concentration at the measured H_2S of 66 ppm likely exceeds 200,000 D/T.

Dewatering room

A sample of the exhaust from the dewatering room or press room shows a moderately high odor concentration of 3,900 D/T, with an H_2S concentration of 1.0 ppm (Sample 5).

Truck bay

The first sample was inadvertently collected when the loading bay doors were open, so it was diluted with clean, outside air and had a low odor concentration of 530 D/T (Sample 4) and no H_2S. The second sample, with doors closed, showed a higher odor concentration of 1,200 D/T, and a field H_2S of 0.3 ppm (Sample 11).

4. ODOR DISPERSION MODELING

4.1 Description of Model

Dispersion modeling is a tool used to predict the downwind concentration of pollutants resulting from the emissions at a source or group of sources. It has been applied to odors by treating odors as a pollutant like hydrogen sulfide, thereby allowing the model to predict the downwind odor "concentration" as a function of distance from the source. These sophisticated computer models use actual meteorological and terrain data to determine how the odors will disperse under worst-case conditions. In addition, the models can be used to determine how frequently a "target" odor level will be exceeded.

For this project, AERMOD was used to predict the impact of the Brattleboro WWTF odor emissions on surrounding neighborhoods. AERMOD is the EPA-specified regulatory model, replacing the Industrial Source Category – Short Term (ISC-ST) model. AERMOD is a Gaussian

dispersion model that is currently the most widely used model in the industry. Input data required for this model include:

- Locations (co-ordinates) of all odor sources
- Odor emission rates (odor concentration x air flow rate) of odor sources
- Stack characteristics (diameter, height, etc.)
- Area source dimensions
- Dimensions of all buildings (to account for building "downwash")
- A full year (2017) of meteorological data from the nearest airport (Orange, MA airport)
- Terrain data for the Brattleboro WWTF site and surrounding areas

The model analyzes a full year of meteorological conditions and selects those worst-case conditions that produce the highest off-site odor level. The worst-case conditions are usually associated with low wind speeds and temperature inversions, i.e. a "stable" atmosphere with little mixing and dispersion. Such conditions often occur during early morning or evening hours.

4.2 Odor Emission Rates

A key variable used in the model is the odor emission rate (OER). Odor emission rate is the product of the odor concentration (D/T) and the air flow rate, so it is akin to the "mass-flow" of odors. OER can be used to rank the sources of odor; however, their downwind impact is also affected by whether the odor source is an area source or point source, the height that the odor is released, the local terrain, and the meteorological conditions. Table 3 provides a ranking of odor sources at the Brattleboro WWTF by odor emission rate.

The digested sludge storage tank is estimated to contribute almost half of the total plant odor emissions. Following that is the primary clarifier effluent channel at 21%. Between the effluent channel and the settling zone, the one primary clarifier accounts for about a quarter (25%) of the total odor emissions from the plant.

The dewatering room, due to the relatively high airflow rate and odor level, is estimated to contribute about 19% of the total plant odor emissions. As opposed to the primary clarifier and digested sludge storage tank that are continuous emissions 24 hr/day, the dewatering room emissions are intermittent and only occur during sludge dewatering. However, due to the design of the Fournier presses, the feed rate is low, so dewatering may occur overnight.

The truck bay exhaust, headworks exhaust, and headworks odor control system collectively contribute less than 15% to the overall odor emissions from the facility.

TABLE 3 RANKING OF SOURCES BY ODOR EMISSION RATE Brattleboro WTTF				
Source	**Odor concentration D/T**	**Air flow rate cfm**	**Odor emission rate D/T x cfm**	**Percent of Total**
1. Digested sludge storage tank	200,000[1]	150[2]	30×10^6	47.9%
2. Primary clarifier effluent channel	60,000	220[2]	13.2×10^6	21.1%
3. Dewatering room exhaust	3.900	3,000[3]	11.7×10^6	18.7%
4. Truck bay exhaust	1,300	3,500[3]	4.5×10^6	7.2%
5. Primary clarifier settling zone	6,900	300[2]	2.1×10^6	3.4%
6. Headworks odor control	2,700	250[3]	0.7×10^6	1.1%
7. Headworks exhaust	1,200	300	0.4×10^6	0.6%
		TOTAL	62.6×10^6	100%

[1] Reported as >60,000 D/T. Estimated based on H_2S concentration

[2] Based on sweep air flow rate in flux chamber

[3] Rated fan capacity

4.3 Predicted Peak Odor Impact

The model predicts the downwind odor concentrations during the worst 1-hour period of the year. Because odor often occur in short-duration "puffs" that may only last a few minutes, a peaking factor of 2.0 was used to convert the average 1-hour peak concentration to a 5-minute peak using a published power law equation.

Figure 5 shows the predicted peak odor concentration during the worst hour of the year. This represents existing conditions as characterized in August, 2018. The model predicted peak odor concentrations of 5 to 20 dilutions to threshold (D/T) in the residential area to the northwest of the plant, from where complaints have originated in the past. An odor concentration of 5 or 7 D/T is often selected as a "target" maximum odor concentration, since at or below this level, odors are barely perceptible and unlikely to cause complaints. Odor concentrations in the 10 to 20 D/T range would be of sufficient intensity to warrant a complaint. As expected, the highest predicted odor concentrations occur closest to the source of odors.

Figure 6 shows the predicted frequency, in hours per year, that a target odor concentration of 7 D/T would be exceeded. The model predicts that, at the residential neighborhood closest to the plant, the 7 D/T target could be exceeded 50 to 200 hours per year.

Some practitioners use a target maximum frequency of one percent of the yearly hours; that is, less than 87 hours per year. The model predicts that this would be exceeded in the residential area immediately northwest of the Brattleboro WWTF.

The odor dispersion model was re-run under the assumption that the open digested sludge storage tank would be covered, resulting in an 80 percent reduction in odor emissions. Figure 7 shows a significant shrinking of the odor "footprint" with control of the storage tank odors. Even more importantly, the frequency that the target 7 D/T odor concentration is exceeded is reduced to below 50 hrs/year in almost all the residential areas, as seen in Figure 8.

A third scenario was evaluated assuming 1) 80 percent control of the sludge storage tank emissions are above, plus 2) 50 percent reduction in primary clarifier emissions through chemical addition or operational changes. (The primary clarifier effluent launder was the second largest source of odors). The model predicts further shrinking of the odor footprint (Figure 9). The frequency that the 7 D/T target is exceeded is predicted to be less than 50 hours per year in all residential areas, as shown in Figure 10.

FIGURE 5. PREDICTED PEAK ODOR CONCENTRATIONS – EXISTING CONDITIONS, D/T

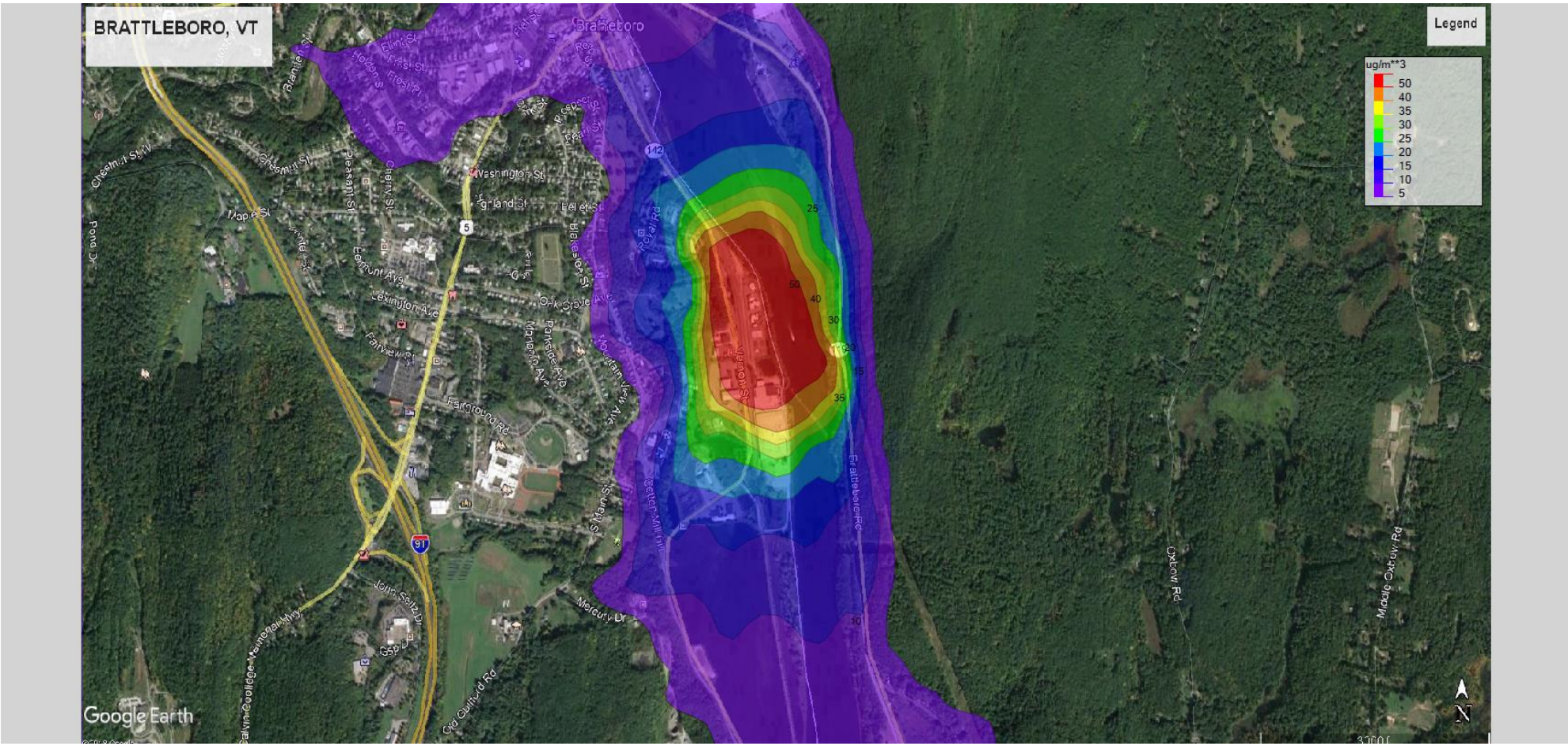


FIGURE 6. PREDICTED FREQUENCY OF EXCEEDING 7 D/T – EXISTING CONDITIONS, HRS/YR

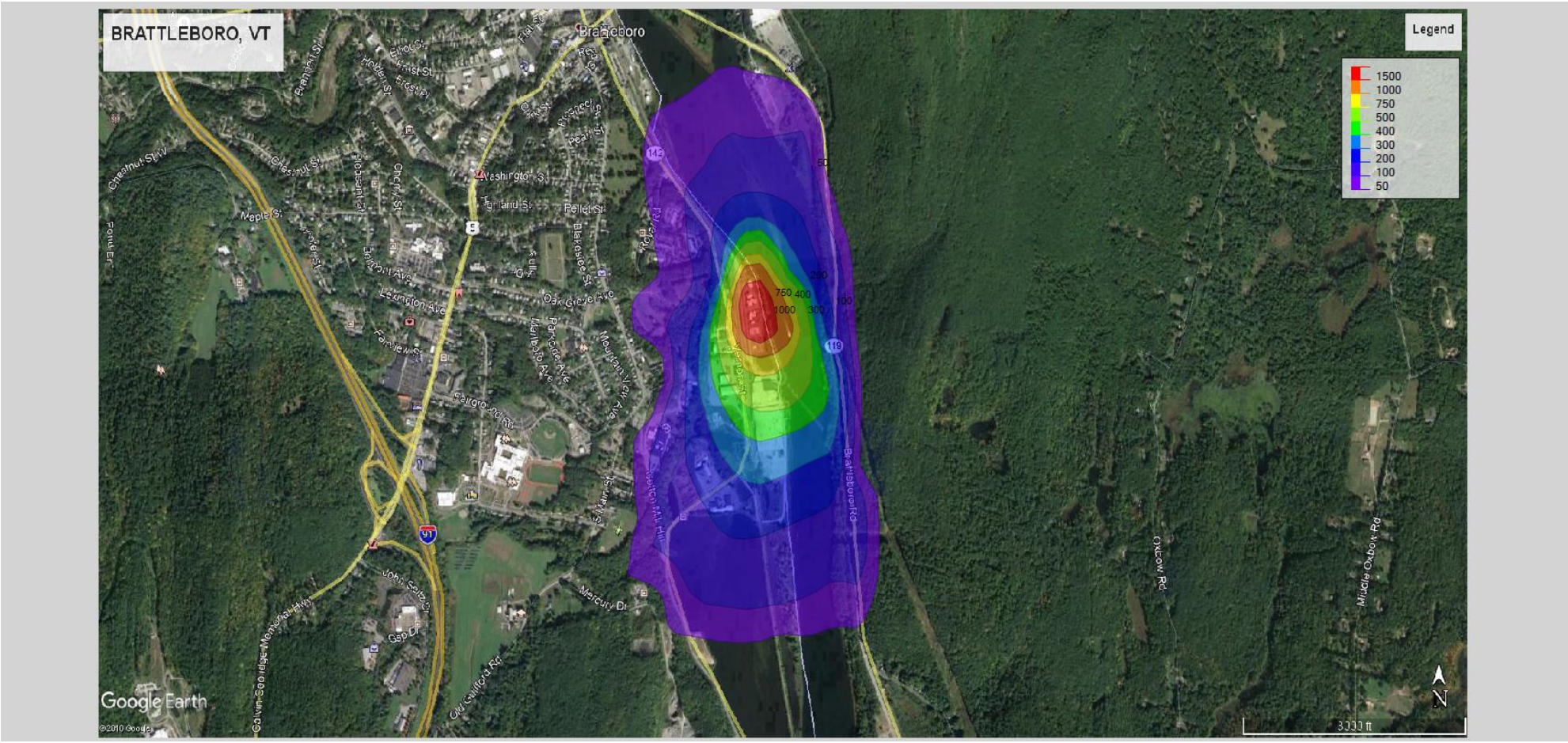


FIGURE 7. PREDICTED PEAK ODOR CONCENTRATION – 80% CONTROL IN HOLDING TANK EMISSIONS, D/T

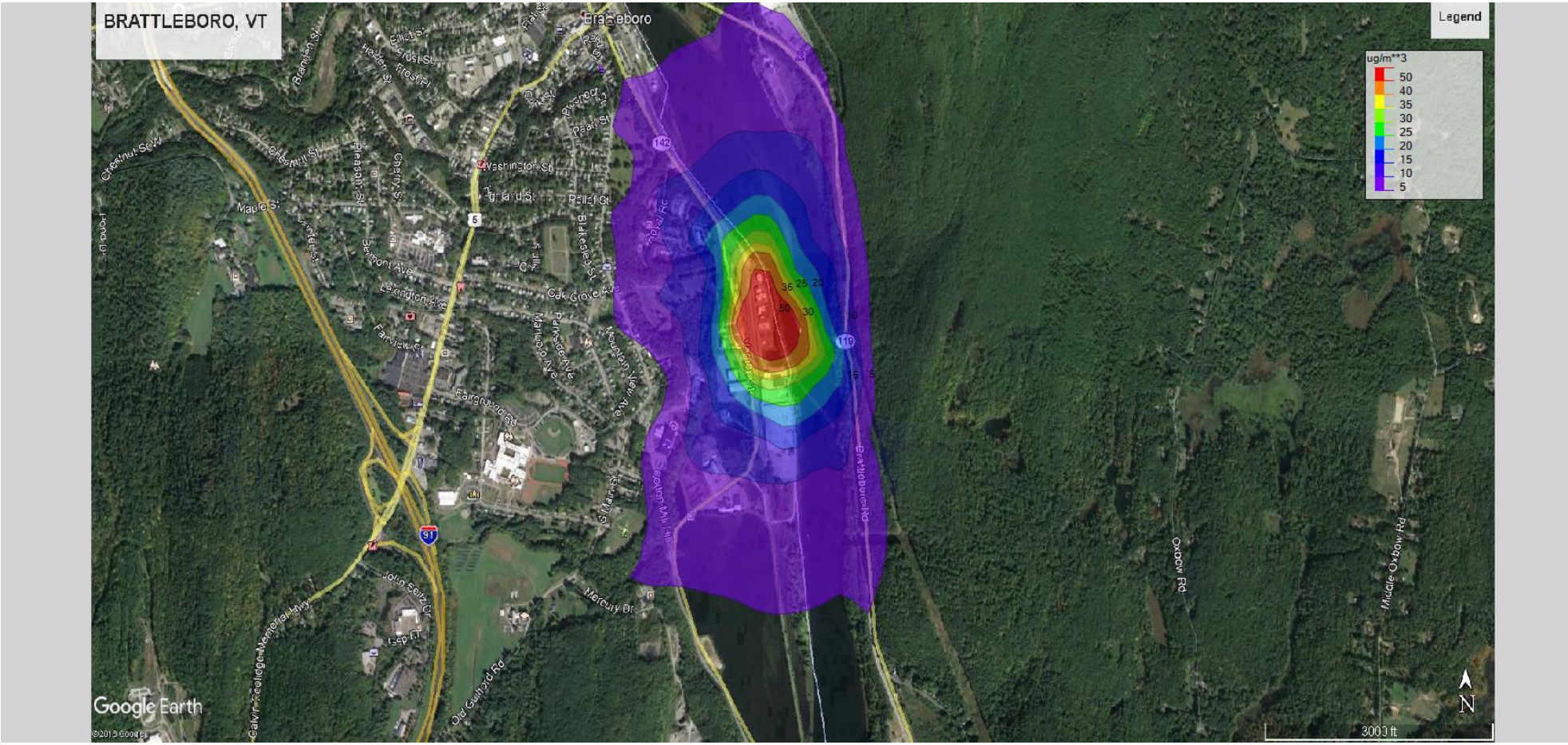


FIGURE 8. PREDICTED FREQUENCY OF EXCEEDING 7 D/T – 80% CONTROL IN HOLDING TANK EMISSIONS, HRS/YR

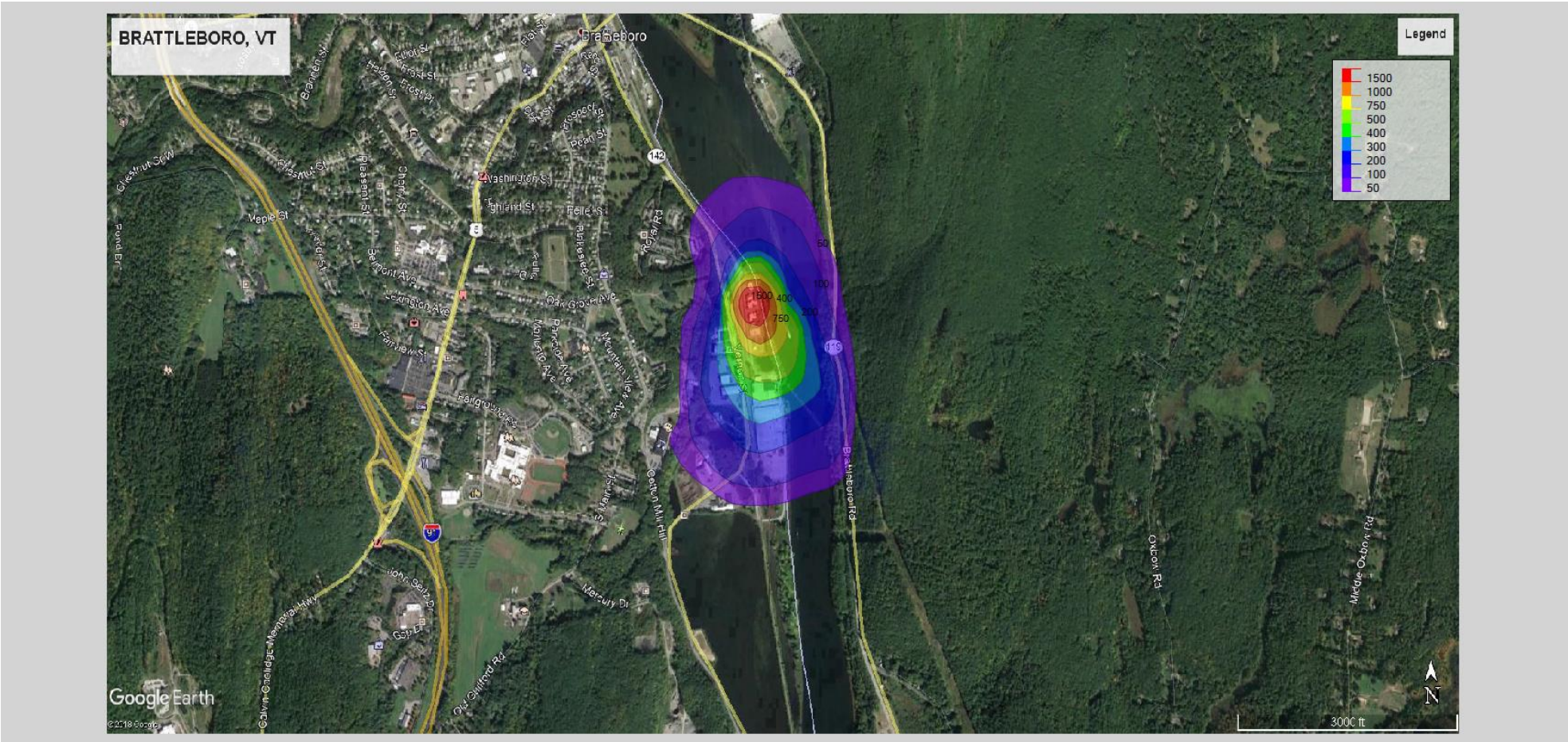


FIGURE 9. PREDICTED PEAK ODOR CONCENTRATION –
80% HOLDING TANK + 50% PRIMARY CLARIFIER CONTROL, D/T

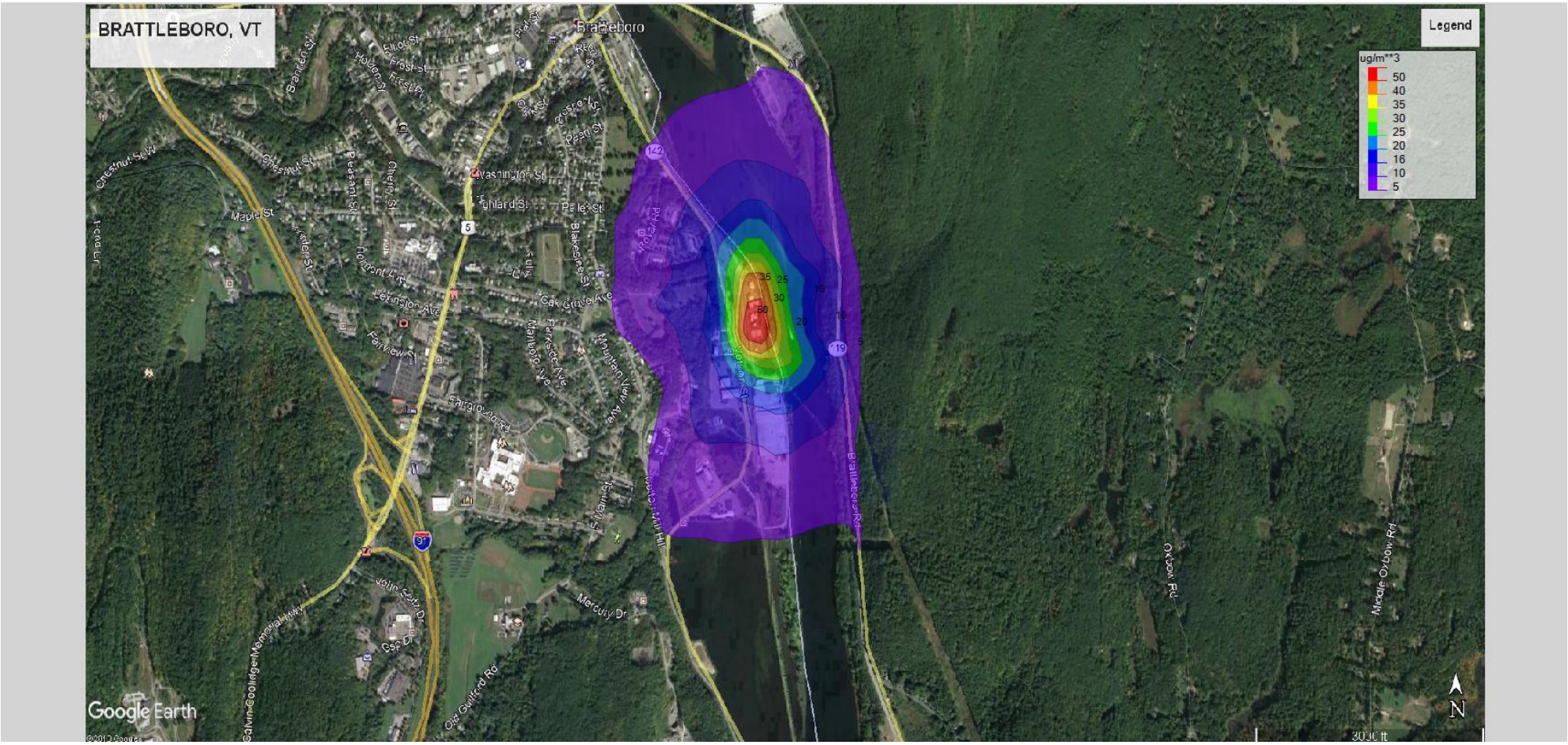
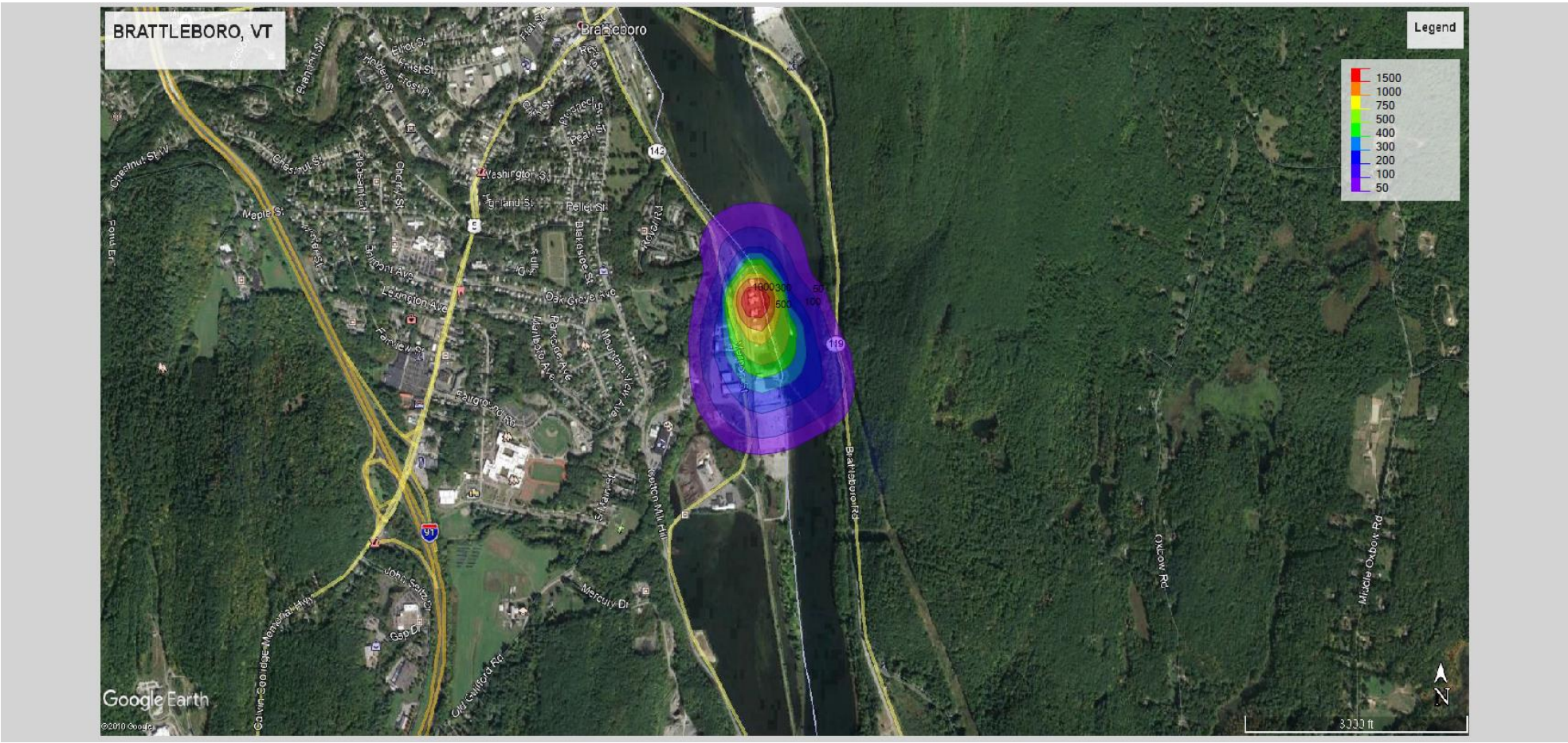


FIGURE 10. PREDICTED FREQUENCY OF EXCEEDING 7 D/T –
80% HOLDING TANK + 50% PRIMARY CLARIFIER CONTROL, HRS/YR



5. EVALUATION OF ODOR CONTROL ALTERNATIVES

5.1 Introduction

The ranking of odor sources in Table 3 showed that the digested sludge storage tank accounted for almost half of the total plant emissions, and the primary clarifier for about a quarter of the emissions. Further, dispersion modeling showed that controlling just the odors from the sludge storage tank significantly reduced the plant's odor footprint. The following is an evaluation of odor control alternatives for the two major sources of odor at the Brattleboro WWTF.

5.2 Digested Sludge Storage Tank

The 35-ft. diameter digested sludge holding tank is open to the atmosphere, and is equipped with a mixer to maintain the sludge in suspension prior to dewatering. Because the sludge in this tank has been anaerobically digested, flammable methane gas is likely to be present. This raises concern with any system designed to contain and/or treat the odorous air.

While chemicals like iron salts can be used to reduce hydrogen sulfide and odor levels, dosages must be closely monitored, actual odor reduction may be limited, and there is a potential impact on dewaterability of the sludge. Containing the odorous emissions with a cover would provide best control of the odors. Due to explosion hazards, mechanical ventilation of the headspace is not recommended. Rather, a passive venting system would allow air to move into and out of the tank depending on whether sludge is being withdrawn from, or pumped into, the tank. Covering of the tank alone is estimated to significantly reduce the volume of air leaving the tank from an estimated 150 cfm to perhaps 30 cfm. This would vary depending on tank operation as well as wind speeds across the vent, but would represent a major reduction in odor emission rate.

Table 4 shows a breakdown of estimated capital cost for an aluminum cover for the digested sludge storage tank. To allow continued access to the mixer, this would be a truss-supported, flat aluminum cover. There would still be some fugitive odor emissions from the vent(s). However the odor emission rate would be significantly reduced due to the low air flow leaving the tank. With a cover and passive vent system, the odor emission rate could be easily measured, and if warranted, a passive odor control system such as a biofilter could be added at a later date.

To ensure compliance with the National Fire Protection Association NFPA-820, the mixer motor may need to be relocated so that it maintains the required 3-ft separation from the cover penetration.

TABLE 4 OPINION OF PROBABLE CAPITAL COST; FLAT ALUMINUM COVER FOR DIGESTED SLUDGE STORAGE TANK; BRATTLEBORO WWTF	
COMPONENT	**COST, $**
1. Contractor mobilization	$ 10,000
2. Materials	$ 88,300[1]
3. Installation @ 40%	$ 35,300
4. Concrete prep/coating @ $20/sf	$ 44,000[2]
	$177,600

[1] Budget estimate of materials by CST, Inc; Conroe, TX.

[2]May not be necessary if existing coating meeting required specifications

Coating of the concrete is often necessary to protect the interior concrete surface from corrosion due to the presence of hydrogen sulfide. In the covered tank, hydrogen sulfide concentrations will be high, and bacteria on the moist walls of the tank will biologically convert the hydrogen sulfide to sulfuric acid. The concrete of the interior walls of the digested sludge storage tank has already been coated. This coating will need to be inspected, and the original specifications reviewed to determine if it can provide the required degree of protection. A cost to recoat the concrete was included in Table 4, but this may not be necessary.

5.3 Primary clarifier

The turbulent effluent launder of the primary clarifier was the second largest source of odors. Although it is possible to install covers over the effluent launders and ventilate the air to a biofilter or other odor control system, such as system is costly to construct and operate. Since the high H_2S emissions appear to be the result of generation within the clarifier, there may be other alternatives to mitigate the odors.

The Town has been using a liquid calcium nitrate product that is added to the influent wastewater. The nitrate serves as an oxygen source for bacteria. When present, the nitrate can promote the oxidation of sulfide as well as prevent the generation of sulfide. The Town was adding 15 to 20 gallons per day to the influent during the summer of 2018.

When the sampling was conducted in August 28029, 2018, Bowker & Associates requested that the chemical be turned off one week prior. After the sampling was completed on the afternoon of August 29, chemical injection was resumed. Inspection of Figure 3 reveals that there may have been *some* reduction in H_2S after chemical addition was resumed, but if so, the reduction was limited.

According to plant staff, secondary sludge is continuously pumped back to the primary clarifier for co-settling. If there was a significant sludge blanket in the secondary clarifier, increased pumping rate might be recommended to prevent the settled solids from going septic. However, this is not the case. Further, sludge blankets in the primary clarifier are checked daily and maintained at about 12 inches, which is acceptable.

It is recommended that the Town further investigate operational and chemical addition alternatives to reduce odor emissions from the primary clarifier. Purchase or rental of an H_2S datalogger is suggested to document improvements. Possible strategies to evaluate include:

1. Increasing the chemical dosage to the influent to 30 gal/d or more during the summer.
2. Relocating the chemical injection point to the secondary sludge return line.
3. Lowering sludge blanket in primary clarifier to minimum acceptable level.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

1. The open storage tank for anaerobically digested sludge is the largest source of odors at the Brattleboro WWTF, accounting for almost half of the total plant odor emissions.

2. The primary clarifier accounts for about 25 percent of the total plant odor emissions.

3. The exhaust from the dewatering room accounts for 15 to 20 percent of total odor emissions, but this only occurs during dewatering operations.

4. The headworks and truck loading bay are not significant contributors to plant odors.

5. The activated carbon media in the headworks odor control system is exhausted.

6. The influent wastewater is relatively "fresh" with no sulfide.

7. The plant receives large volumes of odorous septic tank waste (septage), which is likely increasing the odor potential of the primary clarifier.

8. Although there is little or no sulfide in the influent wastewater, concentrations in the primary effluent were 0.3 to 0.4 mg/L, indicating that sulfide generation is occurring in the primary clarifier.

9. The practice of returning secondary sludge back to the primary clarifier for co-settling likely increases sulfide generation.

10. Chemical addition to the digested sludge storage tank is unlikely to be effective for odor control and could affect sludge dewater ability.

11. Addition of a liquid nitrate product to the influent wastewater may have had a limited effect on H_2S concentrations in the RBC splitter box, but the impact of higher doses should be investigated.

6.2 Recommendations

1. Install a flat cover over the digested sludge storage tank to contain odors. The order-of-magnitude opinion of probable capital cost is $177,600.

2. Maintain access to mixer for maintenance; relocate motor as required by NFPA.

3. Passively vent storage tank headspace to atmosphere without treatment.

4. Conduct additional monitoring of vent emissions as necessary.

5. Evaluate operational and chemical strategies to reduce odor emissions from the primary clarifier.

6. Use datalogging H_2S analyzer at RBC splitter box to document improvements.

7. Replace media in headworks odor control system with high-H_2S capacity activated carbon.