A REVIEW OF AIR QUALITY MODELLING

FOR

POST-FLOOD RESERVOIR DRAWDOWN FUGITIVE DUST

FOR

SPRINGBANK OFF-STREAM RESERVOIR PROJECT

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EXECUTIVE SUMMARY

This report provides a critical review of the fugitive dust emissions and predicted concentrations provided in Alberta Transportation (2018, Exhibit 67).

In brief, the assessment contains the following issues which bias the predicted concentrations:

- Chosen surface roughness to characterize the area where particulate emissions originate.
- The modelling assessment was performed with MM5 (regulatory meteorological data set) without regard to verification with local winds.
- The emissions were assumed to occur only from the area where >10cm of sediment was deposited rather than the flooded area which would be deposited with some level fine silt.
- The particulate size distribution was assumed to be representative of industrial work site emissions; however, the distribution of TSP, PM10 and PM2.5 are more likely represented by silts
- Particles on a surface can be protected by vegetation or form a crusted layer that will increase the threshold friction velocity preventing emissions at lower wind speeds

The above issues result in bias of the emissions lower than what would be expected and predicted concentrations lower than what would be expected.

The report shows that $PM_{2.5}$ and PM_{10} emissions were biased low and modelling assumptions (friction velocity, surface roughness and selected meteorological data) resulted in negligible fugitive dust impacts. With corrections to modelling inputs, it was shown in this re-assessment that the predicted fugitive dust calculations have the potential to predict 'dust-storm' like impacts when fugitive dust controls are not applied and that regulatory limits are likely to be exceeded outside of the project area even with a conservative (over-estimate) of controls in place. Concentrations of TSP, PM10 and PM2.5 are predicted in excess of regulatory objectives for short-term 1 h and 24-hr periods. Due to the uncertain nature of when a flood occurs, the timing of a drawdown, occurrence of rain/snow/freezing and wind, it cannot be predicted with certainty that a fugitive dust clouds will be created for a given 1 h or 24 h period, however, it can be stated that given the number of rain free days, and high wind occurrence, the possibility that dust clouds won't occur is highly unlikely.

Fugitive dust impacts are commonly observed elsewhere for similar reservoir drawdown scenarios and therefore it is expected that the Springbank Reservoir drawdown would result in similar fugitive dust impacts given the generally strong winds in the region.

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1 INTRODUCTION

This report provides a critical review of the fugitive dust emissions and predicted concentrations provided in Alberta Transportation (2018, Exhibit 67).

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- Chosen surface roughness to characterize the area where particulate emissions originate.
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- The particulate size distribution was assumed to be representative of industrial work site emissions; however, the distribution of TSP, PM10 and PM2.5 are more likely represented by silts
- Particles on a surface can be protected by vegetation or form a crusted layer that will increase the threshold friction velocity preventing emissions at lower wind speeds

The above issues result in bias of the emissions lower than what would be expected and predicted concentrations lower than what would be expected. Using the term '*expected*' means that in a post flood scenario, for a large area covered in dried silty material exposed to high winds, it would be *expected* that the results of a dust assessment would result in 'dust-storm like' predictions. These predictions are also *expected* because they are observed in elsewhere in arid regions (for example, Krasnov 2014, Hyde 2018) and reservoir drawdown leads to exposed sediments and frequent dust storms (BC Hydro 2007, 2015, 2018; University of Alberta, 2021). Therefore, the negligible particulate concentration predictions such as those presented in Alberta Transportation (Ex 67) do not make good logical sense.

Investigations of windblown dust events in arid regions of Phoenix and Spokane found that $PM_{2.5}$ constitutes 50% of PM_{10} on dust storm days compared to <30% on non-storm days

(Candis 2011). With 24h PM_{10} concentrations measure up to 803 µg/m³ and 1h concentrations between 1105 µg/m³ and 1879 µg/m³. Krasnov (2014) found that during a study period, daily PM_{10} concentrations ranged from 6 to over 2000 µg/m³ in urban areas. Concentrations of PM_{10} ranged between 1000–5197 µg/m³. Hyde (2018) recorded concentrations up to 9000 µg/m³ resulting from dust storms in Arizona.

A characterization of airborne mineral dusts associated with farm activities in rural Alberta, Canada found that the respirable mass fraction (particles with diameters<5 µm) was greater than 50% for all samples, (Morman and Plumlee, 2013).

The ability to predict the possibility of these dust-storm like effects has importance for public health effects. Breathing natural, or geogenic, dust from natural settings is an emerging public health concern (Morman 2013). Significant increases in emergency hospital admission due to cardiovascular and respiratory diseases are commonly found several days after dust storm episode (example, Tam et al 2012; Ebrahimi et al 2014).

2 DETAILED REVIEW

A summary of the issues in the Alberta Transport (EX 67) report are presented in Table 1.

Table 1. Summary of Issues in Alberta Transport (Ex 67) and Re-Assessment.

Issue	Alberta transport Ex 67	This Re-Assessment
Meteorological Surface Roughness	Zo=0.005 m, Surface roughness based upon micro-scale roughness and perfectly flat *RESULT: under-estimate of emissions*	Zo=0.20 m (areas with vegetation) Zo=0.05 m (areas covered by sediment based upon micro and macro scale effects)
Meteorology	• MM5 (biased low wind speeds) • Peak wind speeds drop in summer *RESULT: under-estimate of emissions*	• Springbank Airport (higher wind speeds) • Wind speeds are greater during warmer mid-day periods when surface would be dry • Peak wind speeds do not drop in summer
Emissions area	• Only where sediment > 10m that buries vegetation • Emissions controls on sediment area 86% *RESULT: under-estimate of emissions*	• Total flooded area divided into: >10cm sediment that buries vegetation, other areas that are silted but vegetation may still be present • Emissions controls on sediment areas 86% • Emission control assuming mostly vegetated 98%
Particle Size Distribution	• Based sieve analysis from Elbow river flowing stream edge • Sieve analysis ignored, and used generic fugitive dust partitions based upon industrial sites *RESULT: under-estimate of emissions*	• Based upon sieve analysis of Glenmore reservoir sediment deposits • Used Glenmore sieve results since this silt layer would be the top layer deposited during hold and draw down
Particle bed aging (coagulation)	• Not accounted for *RESULT: potentially over-estimate of emissions*	• An aging factor was applied taking into account a crust and prevents lower winds from creating emissions • Minimum threshold velocity of 0.75 m/s

Errata

1. Emissions summary table 3.3 (EX 67) shows a column of $PM_{2.5}$ emissions (kg/d). Trivial calculation from the predecessor columns indicates that a factor of $PM_{2.5}$/TSP=0.0375 was used and not $PM_{2.5}$/TSP=0.075 as

per elsewhere in the document. This additional 50% reduction in $PM_{2.5}$ emissions is not otherwise discussed, but appears to be a mis-interpretation as $PM_{2.5}/PM_{10}=0.075$. This error biases the Ex 67 report prediction lower than expected.

2. Control efficiency was presented as 86% but in the emissions summary table, 84% was listed.

2.1 CALCULATION AND METHODS

The particulate emissions model in EX 67 is an acceptable method(s). There are a wide variety of subtle differences in models for predicting fugitive dust emissions and the method chosen can be found in the literature. A review of potential distribution in emissions due to model selection was not performed. The same basic calculations were preformed in this report as per EX 67. For details of the calculation, see EX 67.

The air dispersion modelling in Ex 67 was conducted using an acceptable regulatory model, CALPUFF. The CALPUFF model requires a complex meteorological data set and Alberta Environment and Parks provides a common meteorological data set for all regulatory assessments in Alberta. This requirement reduces some of the variation found when review various applications across the province. The MM5 meteorological data is based upon monitoring data from surface and upper air stations across North America. These data are interpolated using meteorological models (those models similar to what brings us our TV or radio weather forecasts). The MM5 model data available for air dispersion modelling is relatively coarse (12 km), but may be refined to a smaller scale topographical and land use influences using a CALPUFF pre-processing model CALMET. The final meteorological data set result is representative of the wind field at any particular location, but not necessarily a good match. When local data is available, it is always a good idea to compare the MM5 derived meteorology to the local meteorology observations and then determine how the air dispersion modelling may be biased. This important step was not performed in Ex 67 and is discussed further later in this report.

The air dispersion modelling in this report uses the AERMOD model with wind fields created using AERMET and site specific winds from Springbank Airport.

2.2 METEOROLOGICAL SURFACE ROUGHNESS

The surface roughness for the air quality modelling domain is determined by the landuse in the domain. As wind passes from one sufrace type to another, the wind profile redevelops from the ground up at each change in surface. The wind profile above a surface therefore depends upon the fetch since the last surface change, height above the surface, the micro-scale surface characterization and the macro-scale.

Based upon the surface land use in the modeling domain, the surface roughness for the summer seasons (May through October) is 0.2 m as determined by AERflare meteorological processing using circa 2015 land use for the study area.

During a post-flood scenario, sediments are expected to accumulate in the reservoir and Alberta Transportation (Ex 67) provides a prediction of area where deposits are greater than 10 cm for the 100 yr and 200 yr flood events. The model was not able to discern deposits less than this amount. Ex 67 uses this deposition area as the emissions area where the sediments are deep enough to cover local vegetation. The surface landuse, in this case, has now changed on a micro-scale to a sediment covered landscape, but many of the macro-scale features may still be present such as some slopes and ridges. Ex 67 has characterized the surface roughness as 0.005 m which is characteristic of a very flat smooth surface which is not representative of the expected topography and surface. A surface roughness of 0.05 m is more consistent with literature values (US EPA 2020, Scire 2006, AEP 2010, AER 2014). Ex 67 is missing the macro-scale aspect of assigning the surface roughness.

The surface roughness is an important parameter in the fugitive dust emissions. The surface roughness directly impacts the shear stress of the wind profile at the ground level. The shear stress relates to the ability of the wind to dislodge particles which instantiate the saltation process and the overall fugitive dust emissions episode. From a calculation point of view, the shear stress is related to a friction velocity (called U-star, u*) which can be calculated from the surface roughness. Ex 67 provides equations for this calculation. Because Ex 67 underestimated the surface roughness, Ex 67 underestimated the particulate emissions.

2.3 METEOROLOGY

The modelling assessment was performed with MM5 (regulatory meteorological data set) without presenting a review of the local winds nor the implications of differences in the wind fields.

In this case, winds from MM5 are biased low compared to winds measured nearby at the Springbank Airport (see Figure 2 and Table 2). The frequency of occurrence of the maximum wind speed category used by Ex 67 is approximately, P=0.0001. This represents only a single hour per year of the 5-year modelling period (P*8760 hours≈1). Ex 67 presents results using the 99.9th percentile, which excludes the highest 8 hours of predictions. Therefore, the maximum wind speed category emissions are eliminated from the results. The wind data from the Springbank Airport suggests that the probability of the winds at that location are significantly higher. The frequency of the observed winds in the maximum wind speed category is observed to be 0.014 (or 122 hours per per) which would not be removed by filtering the results at the 99.9th percentile.

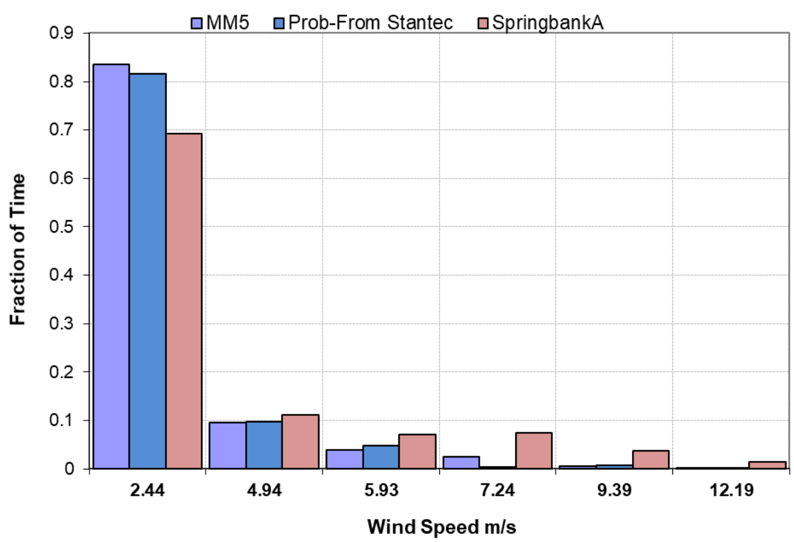

Figure 1. Comparison of Probability of Wind Speed by Category for MM5 (2002-2006), Springbank A (2015-2019) and as reported in Ex 67 (Stantec)

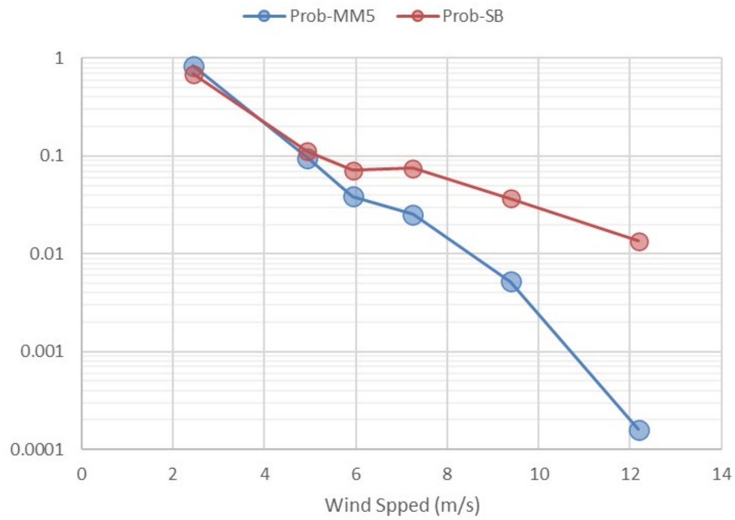

Figure 2. Probability of Wind Speeds using Logarithmic Scale Showing a Comparison of Winds Derived from MM5 (2002-2006) vs Springbank A (SB, 2015-2019) using Wind Speed Categories as per Ex 67

Table 2. Frequency of Wind Speeds Showing a Comparison of Winds Derived from MM5 vs Springbank Airport using Wind Speed Categories s per Ex 67

Wind Speed Category, m/s	Wind Frequency MM5 Data (2002-2006)	Wind Frequency Springbank Airport (2015-2019)
2.44	0.83516	0.69270
4.94	0.09556	0.11104
5.93	0.03870	0.07122
7.24	0.02520	0.07469
9.39	0.00522	0.03665
12.19	0.00016	0.01360

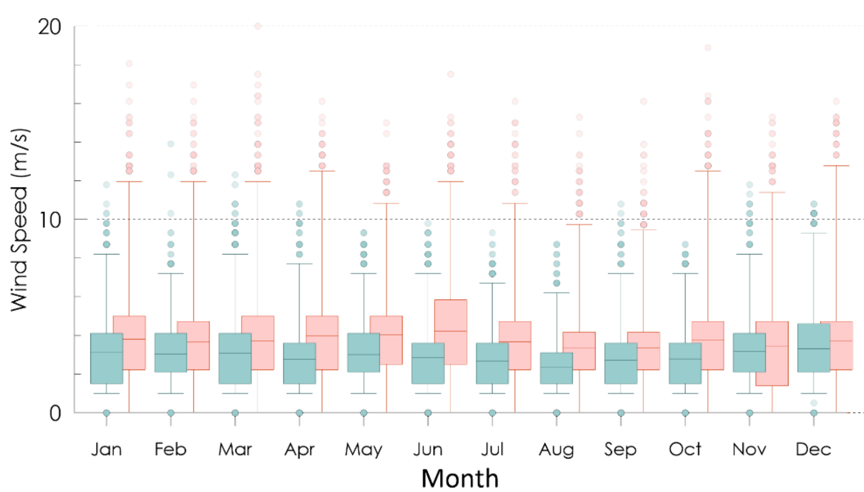

Figure 3. Comparison of Wind Speeds from MM5 (2002-2006) and Springbank A (2015-2019) showing Mean, Quartiles, 1%/99% and outliers as a Function of Month

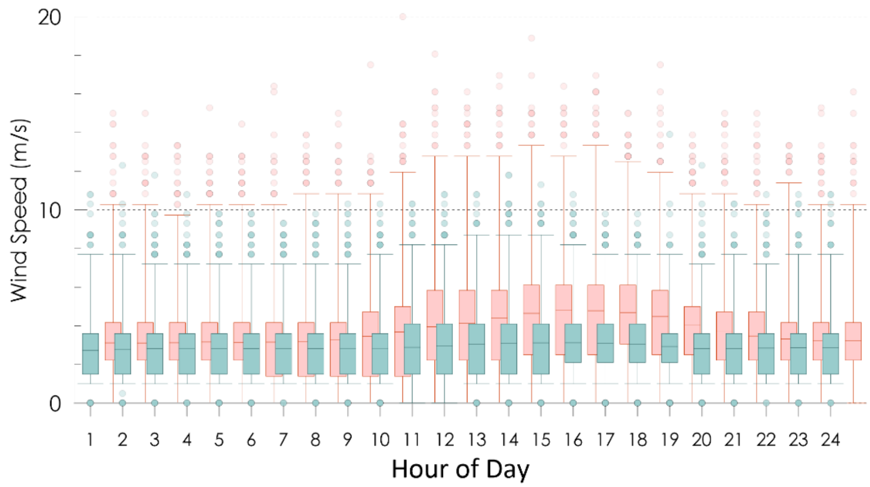

Figure 4. Comparison of Wind Speeds from MM5 (2002-2006) and Springbank A (2015-2019) showing Mean, Quartiles, 1%/99% and outliers as a Function of Hour of Day

2.4 EMISSIONS AREA

The emissions in Ex 67 were assumed to occur only from the area where sediment deposition was greater than 10 cm. The flooded area however, would be deposited with some level fine silt.

The 10 yr, 100 yr and 200 yr flood event areas are shown in Figure 5, Figure 6, and Figure 7, respectively. The flooded areas represent the area that where retained flood water may exist for a several days to weeks allowing silt and sediments to deposit. The depth of sediments in flooded areas was not predictable in the Ex 67 modelling. Some of the vegetation in the flooded is assumed to remain or rebound after the reservoir drawdown. Vegetation is an effective control of fugitive dust, but it is impossible to predict the density of vegetation ground cover. Grantz et al (1998) report a limited data set 91 to 99%, efficiency. Other literature is anecdotal on these effects. For this assessment an efficiency of 98% was adopted which is representation an effective vegetation cover over the entire area.

It is expected that in reality, some areas in the flooded area will have bare patches, dead or dying vegetation. Deep sediments are also expected in low areas, especially in the large borrow pits. Therefore, the control level of 98% is a very conservative estimate which under-estimates the emissions from the large flooded area. The surface roughness in these areas is assumed to be the same as the surrounding area, roughly Zo=0.2 m.

The areas of >10 cm sediments are treated similar to Ex 67. The surface roughness in this area is considered to be Zo=0.05 m. The emissions are evaluated with fugitive dust control (as per Ex 67) of 86% and with out controls.

Table 3. Summary of Emissions Areas

Vegetated Areas	Area (ha)
100 yr >10cm	95.9 [b]
200 yr >10cm	184.6 [b]
10 yr Flooded [a]	60.0
100 yr Flooded [a]	199.5
200 yr (year 2013) Flooded [a]	355.4

[a] Flooded Area excludes sediment >10cm areas

[b] Area(s) are slightly larger than Ex 67 due to digitizing from different source report

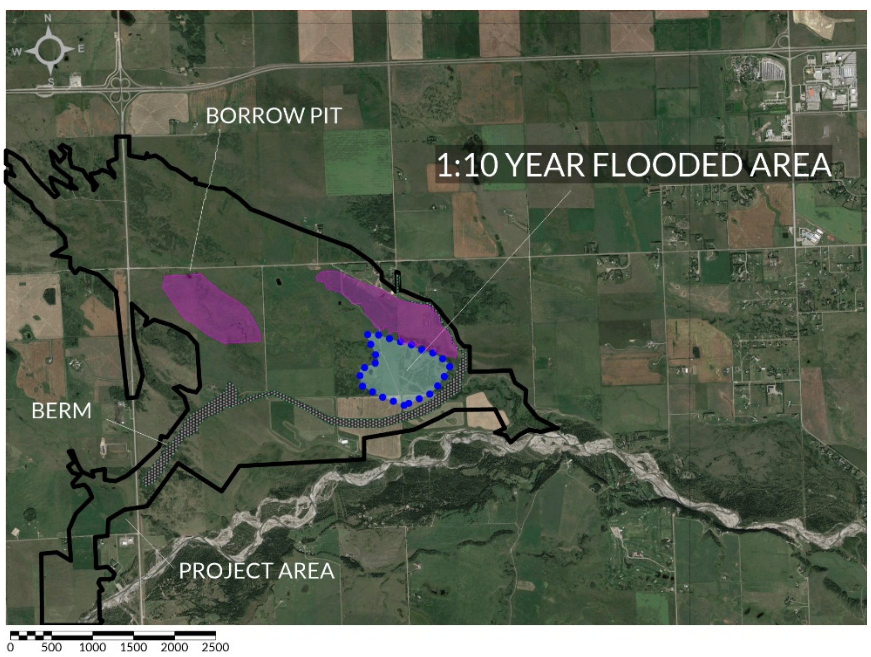

Figure 5. 1 in 10 yr Flooded Area

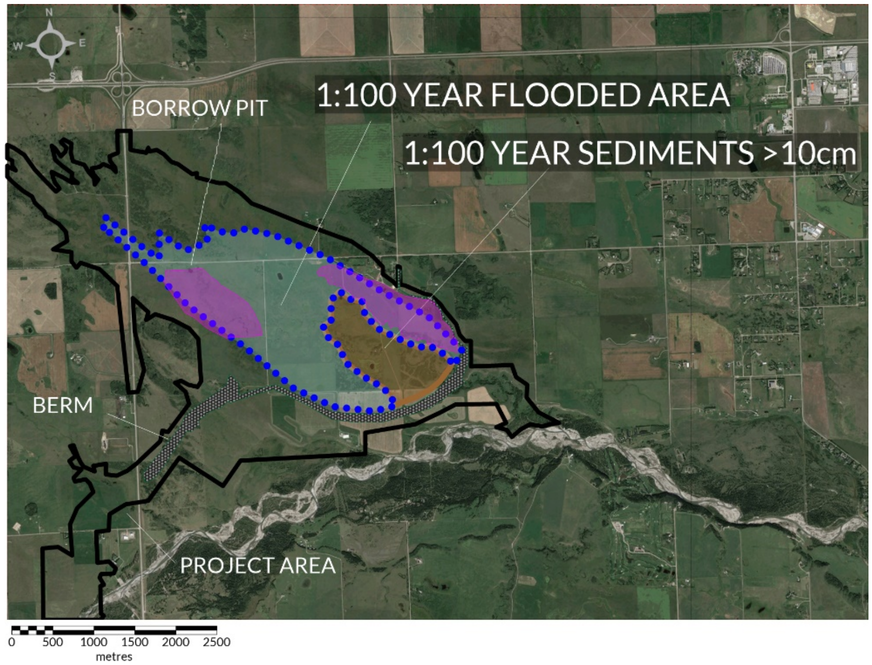

Figure 6. 1 in 100 yr Flooded Area and Sediment Deposition Area

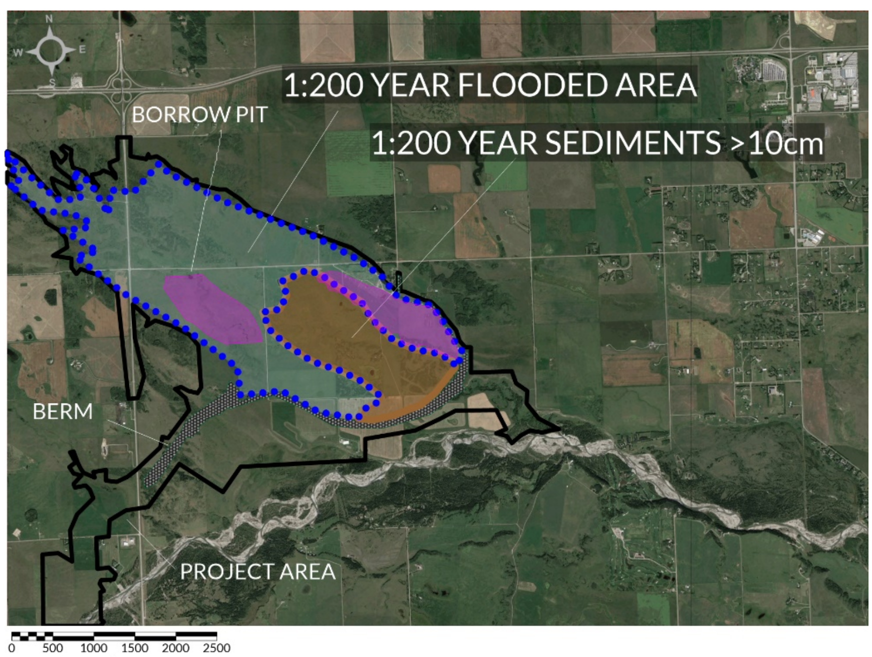

Figure 7. 1 in 200 yr (2013 event) Flooded Area and Sediment Deposition Area

Flocchini et al. (1994) found that the addition of sufficient water to increase the surface moisture content from 0.56% to 2% can achieve greater than 86% reduction in PM_{10} emissions. Ex 67 uses 86% control efficiency for the sediment areas.

2.5 PARTICULATE SIZE DISTRIBUTION

2.5.1 Classification

Ex 67 uses the assumption that the particles were characteristic of sand dunes with an aerodynamic surface roughness of 0.005 cm (50 µm). Ex 67 also references that the hydrological model assessment for the project had identified an approximate composition of post-flood sediment have a mean value of 22% silt and 72% sand based upon sediment sampling along the Elbow river. This gave the sediment a classification of "sandy loam" (type MS) for the emissions flux estimate.

The upper size limit for particles that can become suspended has been estimated at ~75 µm in aerodynamic diameter. Conveniently, 75 µm in physical diameter is also the smallest particle size for which size analysis by dry sieving (200 mesh) is practical. Particles passing a 200-mesh screen on dry sieving are termed "silt", (WRAP 2006). Therefore, the assumption in EX 67 to classify the soils a MS (sandy loam) is not well supported by determined particle size of 50 µm < 75µm, suggesting silt is a better classification.

This assumption is problematic since the deposits from the reservoir would not be expected to be the same as along a flowing river. Specifically, as rivers flow downstream, most natural river bed sediments progressively become finer grained. This phenomenon is referred to as downstream fining, a fluvial process by which finer particles are preferentially transported and deposited downstream. Two main mechanisms are typically attributed to downstream fining: abrasion, where larger particles break into smaller ones, and selective deposition, which describes hydraulically driven sediment fractionation as detailed elsewhere. Larger particles generally deposit upstream, while smaller ones (i.e., fine grained sediments, typically <63 µm) travel further downstream. Thus, these data demonstrate that downstream fining in which suspended solids settle according to size and density (selective sorting) is occurring. (Yang 2018).

In general, as rivers flow into lakes and reservoirs, velocity decreases and the ability to carry larger sediments also decreases. This trend is clear as the D_{50} values observed in the Glenmore reservoir (3.16 µm to 7.23 µm) are all smaller than those in Elbow River (33 µm to 243 µm) (Yang 2018). These results are supported by observations made by Owens et al.

(2005), who observed that sediments deposited in lakes and reservoirs are predominantly fine grained.

From the Glenmore Reservoir sediments data (Yang 2018) a mean aerodynamic diameter for the top most layer of deposits following reservoir drawdown would be expected to be approximately 5 μm as opposed 50 μm in Ex 67.

The aerodynamic roughness diameter is used in the fugitive dust model to estimate the friction threshold velocity. The model presented in EX 67 is not sensitive to particle sizes in that range, therefore the calculated friction threshold velocity roughly the same, u_{*t} =0.20 m/s.

The particle classification is important in the overall classification of the soils available for emissions to the fugitive dust model. Rather than larger particles 'sandy loam' characterization (MS) in Ex 67, the particles from Glenmore Reservoir are better represented by FS (fine silt) or FFS (very fine silts). FS is used in this re-assessment to re-characterize the particulate emissions. From Ex 67, the emissions flux for FS soils is,

$$F = 9.33\text{x}10^{-7}\left(u_*\right)^{2.44} \tag{1}$$

Where u_* (m/s) is the friction velocity derived from meteorology wind field at any particular hour, and emissions flux is g/(cm^2·s). The emissions flux for FS soils is approximately 7.5 times higher than for MS soils used in Ex 67.

2.5.2 Size Distribution

The size distribution of particulates assumed (Ex 67) is based upon generic particulate emissions from AP42 (U.S. EPA 1998) emission factors derived for industrial sites. From AP42, $PM_{2.5}$/TSP=0.075, and the PM_{10}/TSP=0.5. While these figures were derived for industrial sites, this assumption is not supported by numerous literature articles for rural fugitive dust. The assumption should have been verified using site specific information.

The particulate distribution from Glenmore reservoir sediments has a typical diameter of 3-7 μm and with a $PM_{2.5}$ fraction of 28%; and the remaining TSP is largely PM_{10} about 80% (see Figure 8, Yang 2018). Most of most of the particulates are in the inhalable fraction, $PM_{2.5}$ to PM_{10} size range.

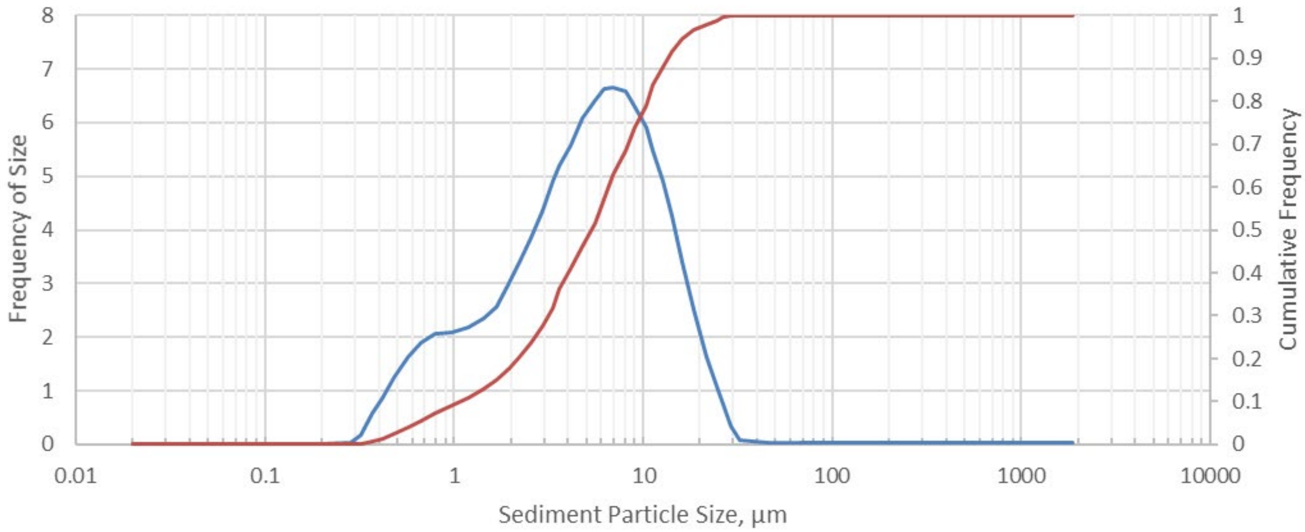

Figure 8. Representative Particle Size Distribution for Sediments in Glenmore Reservoir (Yang 2018)

EX 67 used a $PM_{2.5}$/TSP fraction 0.075. Whereas, this re-assessment will use $PM_{2.5}$/TSP=0.23 based upon Yang (2018). The re-characterization of the $PM_{2.5}$/TSP using relevant site-specific particle size fractions (and similar to expected rural Alberta fraction) increases the emissions of $PM_{2.5}$ from the EX 67 assessment by a factor of 6 (Note $PM_{2.5}$/TSP=0.0375 is reported in Ex 67 emissions summaries).

2.6 PARTICLE BED AGING (COAGULATION)

In general, the particles on a surface can be characterized as ‘fresh’ (or disturbed) or ‘crusted’ (or undisturbed). The classification is important but is not generally provided with reference characterizations for soil types. Based upon the grain size of the surface soils alone, the characterization would be ‘fresh’ and therefore, the drying process is likely to form a crust which would increase the friction velocity threshold and somewhat prevent emissions at lower wind speeds (Gillette 1982, Cowherd 1985). Nonetheless, texture may play an indirect role because crusts able to limit saltation, and hence dust production, are more liable to form on fine textured soils than on coarse texture ones. The influence of crusting is not yet taken into account in the most dust dispersion models, (Alfaro et al 2004).

Based upon the grain size, the friction threshold velocity is estimated to be approximately 0.2 m/s, for the sandy-silt sediment. The effects of soil coagulation can be inferred from

Table 4 (WRAP 2006) as described in Gillette (1982), The average of undisturbed/disturbed ratio from Table 4 is 2.38 (excluding the maximum outlier, prairie soils, which is likely to contain a high clay content).

Table 4. Threshold Friction Velocities for Typical Surface Types (WRAP 2006)

Site Type	Undisturbed u_{*t} (m/s)	Disturbed u_{*t} (m/s)	Ratio Undisturbed/Disturbed
agricultural fields	1.29	0.55	2.35
alluvial fan	0.72	0.6	1.20
desert flat	0.75	0.51	1.47
desert pavement	2.17	0.59	3.68
fan surface	1.43	0.47	3.04
playa, crusted	2.13	0.63	3.38
playa	1.46	0.58	2.52
prairie	2.9	0.24	Excluded 12.08
sand dune	0.44	0.32	1.38
		Average	2.38

For this assessment, the threshold friction velocities are therefore determined as:

$$u_{*t,undisturbed} = 2.38\, u_{*t} \qquad (2)$$

This assumption limits the generation of particulate emissions at low wind speeds which would not have sufficient energy to initiate saltation. The assumption does not increase emissions.

Cowherd (1985) discusses the similar effects of vegetation and crusted or non-crusted soils. Cowherd recommends for crusted soils that a minimum threshold friction velocity of 0.75 m/s be used; which is roughly the same result as in equation (2). A minimum threshold friction velocity (0.75 m/s) was used in this re-assessment for both vegetated areas and for sediment areas. The drying sediment is likely to crust and/or the control applied to the sediments forms a layer resisting emissions at low wind speeds

2.7 SUMMARY OF EMISSIONS

The emissions are summarized in Table 5, with details for the sediment areas (Table 7) and flooded areas (Table 8). The emissions for Ex 67 are presented in Ex 67 (Table 6) for comparison. Overall, the emissions in Ex 67 were underestimated for $PM_{2.5}$ and PM, and over estimated for TSP, see Table 5. The principal reason for the differences in the emission is the effected of limiting threshold friction velocity, 0.75 m/s. The effect on emissions is seen in comparing Table 6 and Table 7 for wind speed categories <11 m/s. These lower wind speeds have a surface friction velocity less than the threshold friction velocity 0.75 m/s to initiate saltation and particulate emissions, therefore the emissions are zero. In the Ex 67 assessment, however, the high probability of low windspeeds and lack of limiting threshold friction velocity resulted in large potential emissions.

Table 5. Summary of Emissions Comparison Between EX 67 and this Re-Assessment with Controls

Report	Year	**PM2.5 (kg/d)**	**PM10 (kg/d)**	**TSP (kg/d)**
Ex 67	100	9	115	231
	200	16	218	437
This Re-Assessment	10	4	15	19
	100	43	149	186
	200 [a]	80	279	349

a Based upon area flooded in 2013, sediment deposition area as predicted for year 200.

Table 6. Project Emissions Rates (See Table 3-3, Ex 67)

Flood Scenario	Sediment Area [a]	Wind Speed Category	Lower Limit Wind Speed	Upper Limit Wind Speed	Mean Wind Speed [b]	Wind Probability [c]	Wind Speed Dependent Emission Rate	Emission Rate without Dust Mitigation [e]			Dust Control Efficiency [d, f]	Emission Rate with Applied Dust Mitigation		
								$PM_{2.5}$	PM_{10}	TSP		$PM_{2.5}$	PM_{10}	TSP
	(m²)	—	(m/s)	(m/s)	(m/s)	(%)	g/(m²·h)	(kg/d)			(%)	(kg/d)		
Sediment (Buried Vegetation) 1:100 year flood	820,578	1	0	4.5	2.44	81.6	0	0.0	0.0	0.0	84	0.0	0.0	0.0
		2	4.5	5.5	4.94	9.7	0.235	16.8	224.5	448.9		2.7	35.9	71.8
		3	5.5	6.5	5.93	4.8	0.381	13.5	180.1	360.2		2.2	28.8	57.6
		4	6.5	8.5	7.24	3.1	0.645	14.8	196.9	393.8		2.4	31.5	63.0
		5	8.5	11	9.39	0.73	1.281	6.9	92.1	184.2		1.1	14.7	29.5
		6	11	17	12.19	0.11	2.553	2.1	27.7	55.3		0.3	4.4	8.8
		Total Emissions:				1.00		54.1	721.2	1442.3		8.7	115.4	230.8
Sediment Buried Vegetation) Design flood 1:200 (y2013)	1,553,792	1	0	4.5	2.44	81.6	0	0.0	0.0	0.0	84	0.0	0.0	0.0
		2	4.5	5.5	4.94	9.7	0.235	31.9	425.0	850.0		5.1	68.0	136.0
		3	5.5	6.5	5.93	4.8	0.381	25.6	341.0	682.0		4.1	54.6	109.1
		4	6.5	8.5	7.24	3.1	0.645	28.0	372.8	745.6		4.5	59.7	119.3
		5	8.5	11	9.39	0.73	1.281	13.1	174.4	348.7		2.1	27.9	55.8
		6	11	17	12.19	0.11	2.553	3.9	52.4	104.7		0.6	8.4	16.8
		Total Emissions:				1.0		102.4	1365.6	2731.1		16.4	218.5	437.0

NOTES:
[a] Sediment area corresponding to sediment depth equal or greater than 0.10 m.
[b] Mean wind speed for each wind speed category calculated from CALMET 5-year time series at the approximate center of the sediment area in the off-stream reservoir.
[c] Probability of wind within each wind speed category estimated from CALMET 5-year time series at the approximate center of the sediment area in the off-steam reservoir.
[d] Control efficiency corresponds to application of chemical dust suppressant (i.e. tackifier).

[e] Particulate Size fractions applied in table $PM_{2.5}$, PM_{10}, TSP: 0.0375, 0.5 and 1.
[f] Control efficiency from for tackifier is 84% whereas previously in Ex 67 defined as 86%

Table 7. Emission Rates for >10cm Sediment (Buried Vegetation) Areas

Flood Scenario	Sediment Area [a]	Wind Speed Category	Lower Limit Wind Speed	Upper Limit Wind Speed	Mean Wind Speed [b]	Wind Probability [c]	Wind Speed Dependent Emission Rate	Emission Rate without Dust Mitigation [e]			Dust Control Efficiency [d]	Emission Rate with Applied Dust Mitigation		
								$PM_{2.5}$	PM_{10}	TSP		$PM_{2.5}$	PM_{10}	TSP
	(m²)	—	(m/s)	(m/s)	(m/s)	(%)	g/(m²·h)	(kg/d)			(%)	(kg/d)		
Sediment (Buried Vegetation) 1:100 year flood	959,000	1	0	4.5	2.44	0.693	0	0.0	0.0	0.0	86	0.0	0.0	0.0
		2	4.5	5.5	4.94	0.111	0	0.0	0.0	0.0		0.0	0.0	0.0
		3	5.5	6.5	5.93	0.071	0	0.0	0.0	0.0		0.0	0.0	0.0
		4	6.5	8.5	7.24	0.075	0	0.0	0.0	0.0		0.0	0.0	0.0
		5	8.5	11	9.39	0.037	25.50	49.5	172.1	215.1		6.9	24.1	30.1
		6	11	17	12.19	0.014	48.20	34.7	120.7	150.9		4.9	16.9	21.1
		Total Emissions:				1.00		84.2	292.8	366.0		11.8	41.0	51.2
Sediment Buried Vegetation) Design flood 1:200 (y2013)	1,846,000	1	0	4.5	2.44	0.693	0	0.0	0.0	0.0	86	0.0	0.0	0.0
		2	4.5	5.5	4.94	0.111	0	0.0	0.0	0.0		0.0	0.0	0.0
		3	5.5	6.5	5.93	0.071	0	0.0	0.0	0.0		0.0	0.0	0.0
		4	6.5	8.5	7.24	0.075	0	0.0	0.0	0.0		0.0	0.0	0.0
		5	8.5	11	9.39	0.037	25.50	95.2	331.2	414.0		13.3	46.4	58.0
		6	11	17	12.19	0.014	48.20	66.8	232.4	290.4		9.4	32.5	40.7
		Total Emissions:				1.0		162.0	563.6	704.4		22.7	78.9	98.6

NOTES:
[a] Sediment area corresponding to sediment depth equal or greater than 0.10 m, excluding areas with tall shrubs/vegetation.
[b] Mean wind speed for each wind speed category adopted from EX 67.
[c] Probability of wind within each wind speed category estimated from Springbank Airport (2015-2019)
[d] There is no control efficiency
[e] Particulate Size fractions applied in table $PM_{2.5}$, PM_{10}, TSP: 0.23, 0.8 and 1; based upon Glenmore Reservoir sediments samples

Table 8. Emission Rates for Flooded Areas (Vegetation Exposed through Silt/Sediments)

Flood Scenario	Sediment Area [a]	Wind Speed Category	Lower Limit Wind Speed	Upper Limit Wind Speed	Mean Wind Speed [b]	Wind Probability [c]	Wind Speed Dependent Emission Rate	Emission Rate without Dust Mitigation [e] PM$_{2.5}$	Emission Rate without Dust Mitigation [e] PM$_{10}$	Emission Rate without Dust Mitigation [e] TSP	Dust Control Efficiency [d]	Emission Rate with Applied Dust Mitigation PM$_{2.5}$	Emission Rate with Applied Dust Mitigation PM$_{10}$	Emission Rate with Applied Dust Mitigation TSP
	(m²)	—	(m/s)	(m/s)	(m/s)	(%)	g/(m²·h)	(kg/d)			(%)	(kg/d)		
Vegetation Exposed 1:100 year flood	600,000	1	0	4.5	2.44	0.693	0	0.0	0.0	0.0	98	0.0	0.0	0.0
		2	4.5	5.5	4.94	0.111	0	0.0	0.0	0.0		0.0	0.0	0.0
		3	5.5	6.5	5.93	0.071	17.41	41.1	142.9	178.6		0.8	2.9	3.6
		4	6.5	8.5	7.24	0.075	28.34	70.1	243.8	304.8		1.4	4.9	6.1
		5	8.5	11	9.39	0.037	53.45	64.9	225.7	282.1		1.3	4.5	5.6
		6	11	17	12.19	0.014	101.04	45.5	158.3	197.9		0.9	3.2	4.0
		Total Emissions:				1.00		221.6	770.7	963.4		4.4	15.4	19.3
Vegetation Exposed 1:100 year flood	3,774,000	1	0	4.5	2.44	0.693	0	0.0	0.0	0.0	98	0.0	0.0	0.0
		2	4.5	5.5	4.94	0.111	0	0.0	0.0	0.0		0.0	0.0	0.0
		3	5.5	6.5	5.93	0.071	17.41	258.4	898.7	1123.3		5.2	18.0	22.5
		4	6.5	8.5	7.24	0.075	28.34	441.0	1533.8	1917.2		8.8	30.7	38.3
		5	8.5	11	9.39	0.037	53.45	408.1	1419.4	1774.3		8.2	28.4	35.5
		6	11	17	12.19	0.014	101.04	286.3	995.8	1244.7		5.7	19.9	24.9
		Total Emissions:				1.00		1393.7	4847.6	6059.5		27.9	97.0	121.2
Vegetation Exposed Design flood 1:200 (y2013)	5,967,000	1	0	4.5	2.44	0.693	0	0.0	0.0	0.0	98	0.0	0.0	0.0
		2	4.5	5.5	4.94	0.111	0	0.0	0.0	0.0		0.0	0.0	0.0
		3	5.5	6.5	5.93	0.071	17.41	408.5	1420.9	1776.1		8.2	28.4	35.5
		4	6.5	8.5	7.24	0.075	28.34	697.2	2425.0	3031.3		13.9	48.5	60.6
		5	8.5	11	9.39	0.037	53.45	645.2	2244.2	2805.2		12.9	44.9	56.1
		6	11	17	12.19	0.014	101.04	452.6	1574.4	1968.0		9.1	31.5	39.4
		Total Emissions:				1.0		2203.5	7664.5	9580.6		44.1	153.3	191.6

NOTES:
[a] Sediment area corresponding to flooded areas that may have vegetation exposed.
[b] Mean wind speed for each wind speed category adopted from EX 67.
[c] Probability of wind within each wind speed category estimated from Springbank Airport (2015-2019)
[d] There is no control efficiency
[e] Particulate Size fractions applied in table PM$_{2.5}$, PM$_{10}$, TSP: 0.23, 0.8 and 1; based upon Glenmore Reservoir sediments samples

3 MODELLING RESULTS

To verify the modelling methods in this report, the same conditions and emissions as those presented in Ex 67 were remodelled. Figure A1 and Figure A2 recreate the results for EX 67 for the 1h 99.9th percentile $PM_{2.5}$ predictions for 100 yr and 200 yr flood, respectively, using MM5 meteorology. These predictions assume that fugitive dust is only emitted from the area with sediment >10 cm, post flood. The results agree well with Ex 67 and show that regulatory limits are not predicted to be exceeded beyond the flooded area.

Figure A3 and Figure A4 (1h 99.9th $PM_{2.5}$ 100 yr and 200yr, respectively) show the air concentration prediction results including the resolved issues related to roughness, friction velocity and wind speeds while keeping the same assumption of emissions from the area with sediments >10 cm only. These more realistic predictions of Ex 67 results show that regulatory limits are exceed beyond the Project Area. In this scenario, the emissions for $PM_{2.5}$ are greater than Ex 67 because Ex 67 assumed a very low $PM_{2.5}$ fraction (0.0375 or TSP) whereas this assessment used data from Glenmore reservoir ($PM_{2.5}$ fraction 0.23 of TSP). Also included in these results is the effect of increased wind speeds using the Springbank Airport data which includes a higher probability of winds greater than 11 m/s and which were removed from analysis in the 99.9th percentile of the EX 67 results.

Figure A5 and Figure A6 (1h 99.9th $PM_{2.5}$ 100 yr and 200 yr, respectively) show the air concentration prediction results similar to Figure A3 and Figure A4, except no controls were applied to the sediments to reduce fugitive dust. These results show dust-storm like conditions with concentrations greater than regulatory limits. These predictions agree anecdotally with observations of dust from similar uncontrolled arid and draw down reservoirs, previously discussed. It is clear from these results that some form of control must be promptly applied to prevent dust clouds during dry summer periods to prevent impacts to public areas.

With dust suppression controls in place on areas with sediments >10 cm, Figure A7, Figure A8 and Figure A9 show the predicted air concentrations including fugitive dust from the entire flooded areas (10 yr, 100 yr and 200 yr floods, respectively). Results are presented for 1h 99.9th $PM_{2.5}$, 24h 98th $PM_{2.5}$, 1 h 99.9 TSP and 24 h TSP for each scenario. These modelling predictions account for silt deposits on the entire flooded area, while assuming a both a high friction velocity threshold (applicable to vegetation protection and/or crusted deposits) and also a high control effectiveness of vegetation (98%). The vegetation that remains post-flood will be a function many factors including: the duration of water retention, depth of water cover, variety of vegetation able to withstand flooding events, depth of silt or sediment deposits, etc. Therefore, some areas of the post flood reservoir it is likely that emissions could be greater than modelled in these scenarios. All of the modelling scenarios that include the entire post flood and silted areas and high level of controls, are predicted to exceed regulatory limits beyond the Project Area and may impact residential locations.

3.1 MITIGATING FACTORS – RAIN

Due to the size of the large area of emissions, it may not be feasible to apply dust suppression such as watering, tackifiers or hydro-seeding following each season of post-flood cleanup.

The duration and amount of precipitation and snow and freeze events will affect the dust emissions from wind erosion. WRAP (2006). WRAP mentions, but does not provide data for, how the seasons, soil characteristics and the amounts of rainfall and snow cover impact emissions. Most literature discusses anecdotal evidence that watering (and frozen moist soil) will limit the emissions of fugitive particulates as long as the soil maintains the moisture. The time necessary to re-initiate wind erosion after a precipitation event ranges from 1 to 10 days, depending on the soil type, season of the year and whether the rainfall amount exceeds 2 inches (WRAP 2006). From this it can be deduced that for rainfall less than 2 inches, the time period to re-initiate wind erosion may be less than one day. Active construction and earthworks areas, frequently require two to three water sprayings per day, depending upon the conditions.

The Springbank Airport (2015-2019) recorded rain and snow days as shown in Figure 9 and Figure 10, respectively. These figures show that many days occur without rain. Figure 11 shows the number of days since the last rain or snow event and shows on average at least two days of drying time is greater than 10 times per month. Given the high winds Figure 3 observed in each of the summer months and the number of dry days, there is a high possibility of a strong fugitive dust emissions with or without successful emissions control.

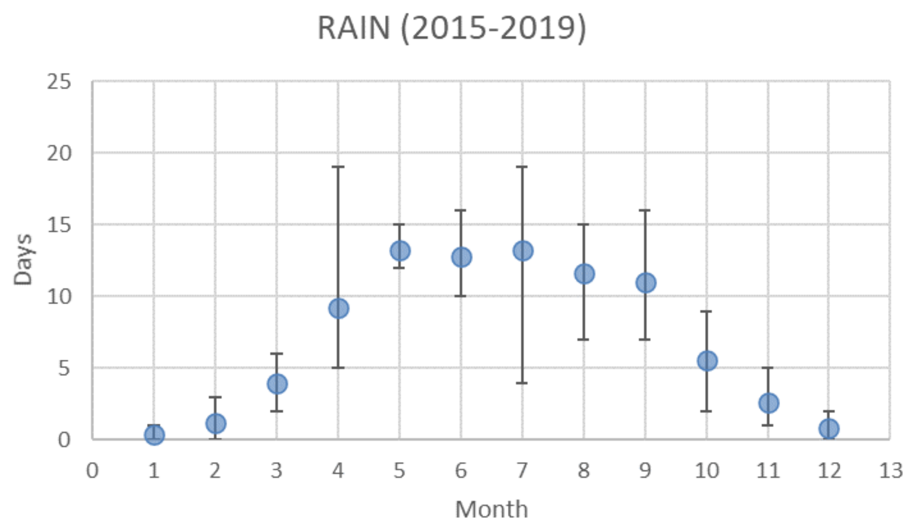

Figure 9. Days with Rain

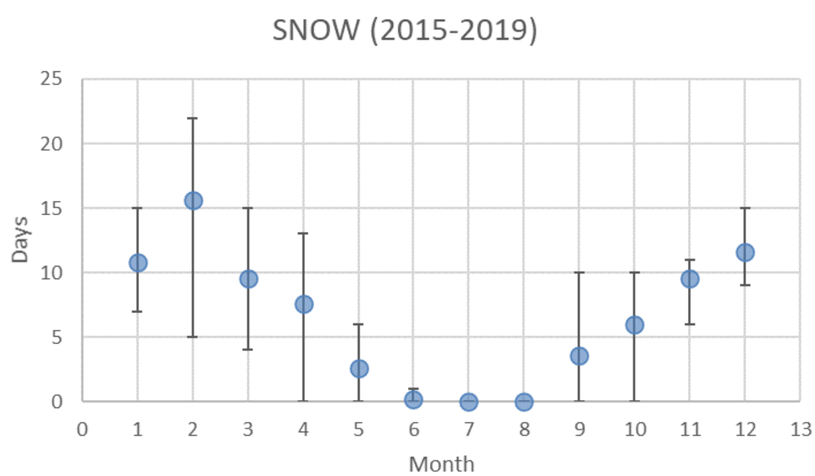

Figure 10. Days with Snow Fall

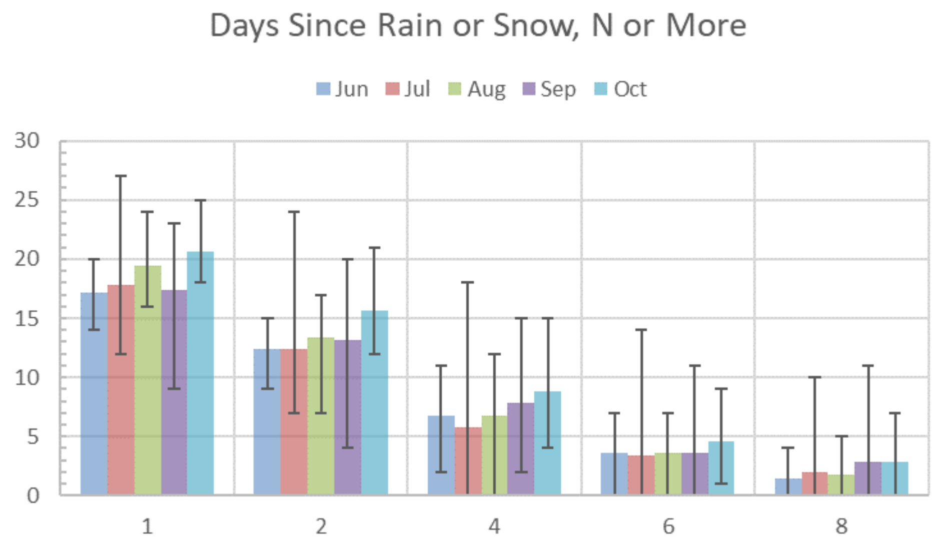

Figure 11. Days Since Last Rain or Snow

4 CONCLUSIONS

This report has presented several issues with Alberta transport Ex 67 report. It was shown that $PM_{2.5}$ and PM_{10} emissions were biased low and modelling assumptions (friction velocity, surface roughness and selected meteorological data) resulted in negligible fugitive dust impacts. With corrections to modelling inputs, it was shown in this re-assessment that the predicted fugitive dust calculations have the potential to predict 'dust-storm' like impacts when fugitive dust controls are not applied and that regulatory limits are likely to be exceeded outside of the project area even with a conservative (over-estimate) of controls in place. Concentrations of TSP, PM10 and PM2.5 are predicted in excess of regulatory objectives for short-term 1 h and 24-hr periods. Due to the uncertain nature of when a flood occurs, the timing of a drawdown, occurrence of rain/snow/freezing and wind, it cannot be predicted with certainty that a fugitive dust clouds will be created for a given 1 h or 24 h period, however, it can be stated that given the number of rain free days, and high wind occurrence, the possibility that dust clouds won't occur is highly unlikely.

Fugitive dust impacts are commonly observed elsewhere for similar reservoir drawdown scenarios and therefore it is expected that the Springbank Reservoir drawdown would result in similar fugitive dust impacts given the generally strong winds in the region.

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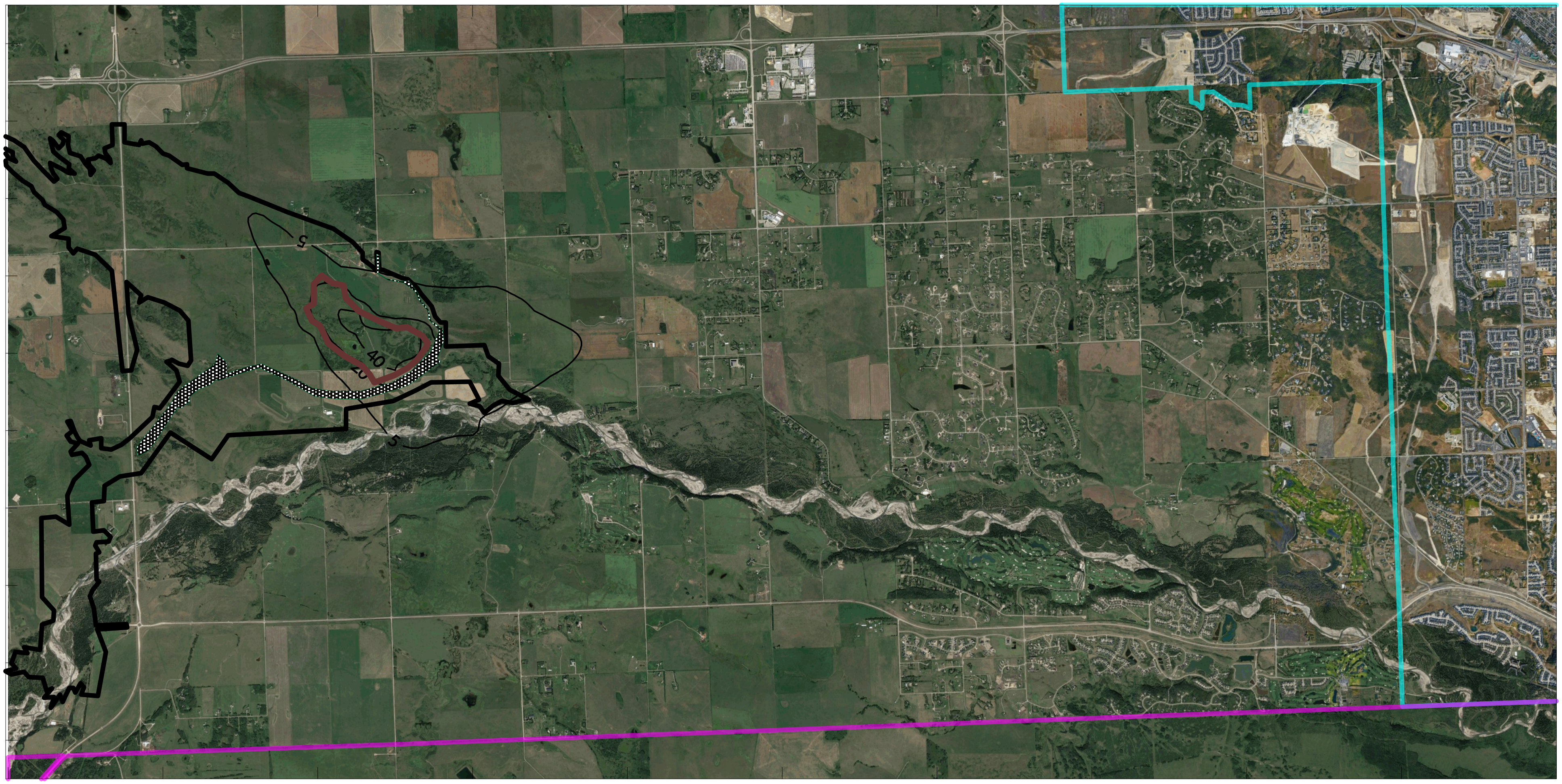
APPENDIX A – FUGITIVE DUST AIR DISPERSION MODELLING PREDICTIONS



LEGEND

- PROJECT AREA
- CALGARY CITY LIMITS (2018)
- FIRST NATIONS
- FLOODED AREA
- DEEP SEDIMENT (>10cm)

µg/m³: 0, 5, 20, 40, 80, 200, 500, 1000, 5000, 10000

EMISSION: $PM_{2.5}$
TIME AVERAGE: 1h Average (99.9th percentile)
MAXIMUM CONCENTRATION: 49.2 µg/m³
OBJECTIVE: 80 µg/m³
BACKGROUND: 0 µg/m³
MODEL: AERMOD (18081)

N

Date: 18-Feb-2021

Zelt psi

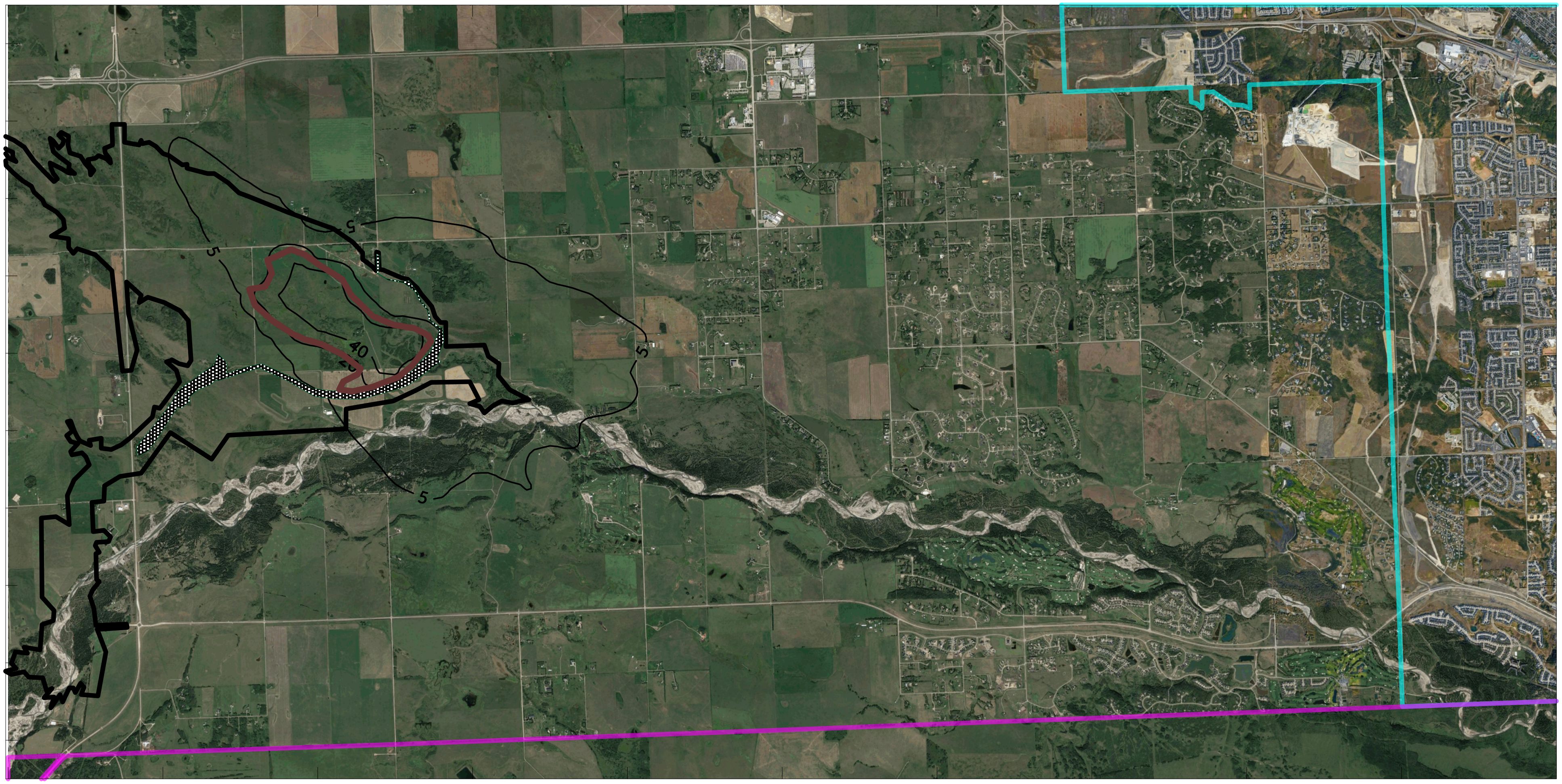
Drawn By:

METRES
0 1000 2000 3000 4000 5000

NAD83 UTM 11, BASEMAP: GOOGLE EARTH
FILE: P:/2021/2100300-SPRINGBANKDAM/CALCS/AERMOD/S100/PM/P0999_PM25_TALLVEG.SRF

Re-Examination of Post Flood Dry Reservoir Sediment Particulate Emissions SPRINGBANK OFF-STREAM RESERVOIR PROJECT

FIGURE A1:
Re-Run of 100yr flood
9th Highest (99.9th %)1h Average
Predicted PM2.5 Concentrations



LEGEND

- PROJECT AREA
- CALGARY CITY LIMITS (2018)
- FIRST NATIONS
- FLOODED AREA
- DEEP SEDIMENT (>10cm)

μg/m³: 0, 5, 20, 40, 80, 200, 500, 1000, 5000, 10000

EMISSION: $PM_{2.5}$
TIME AVERAGE: 1h Average (99.9th percentile)
MAXIMUM CONCENTRATION: 51.8 μg/m³
OBJECTIVE: 80 μg/m³
BACKGROUND: 0 μg/m³
MODEL: AERMOD (18081)

N

Date: 18-Feb-2021

Zelt psi

Drawn By:

METRES

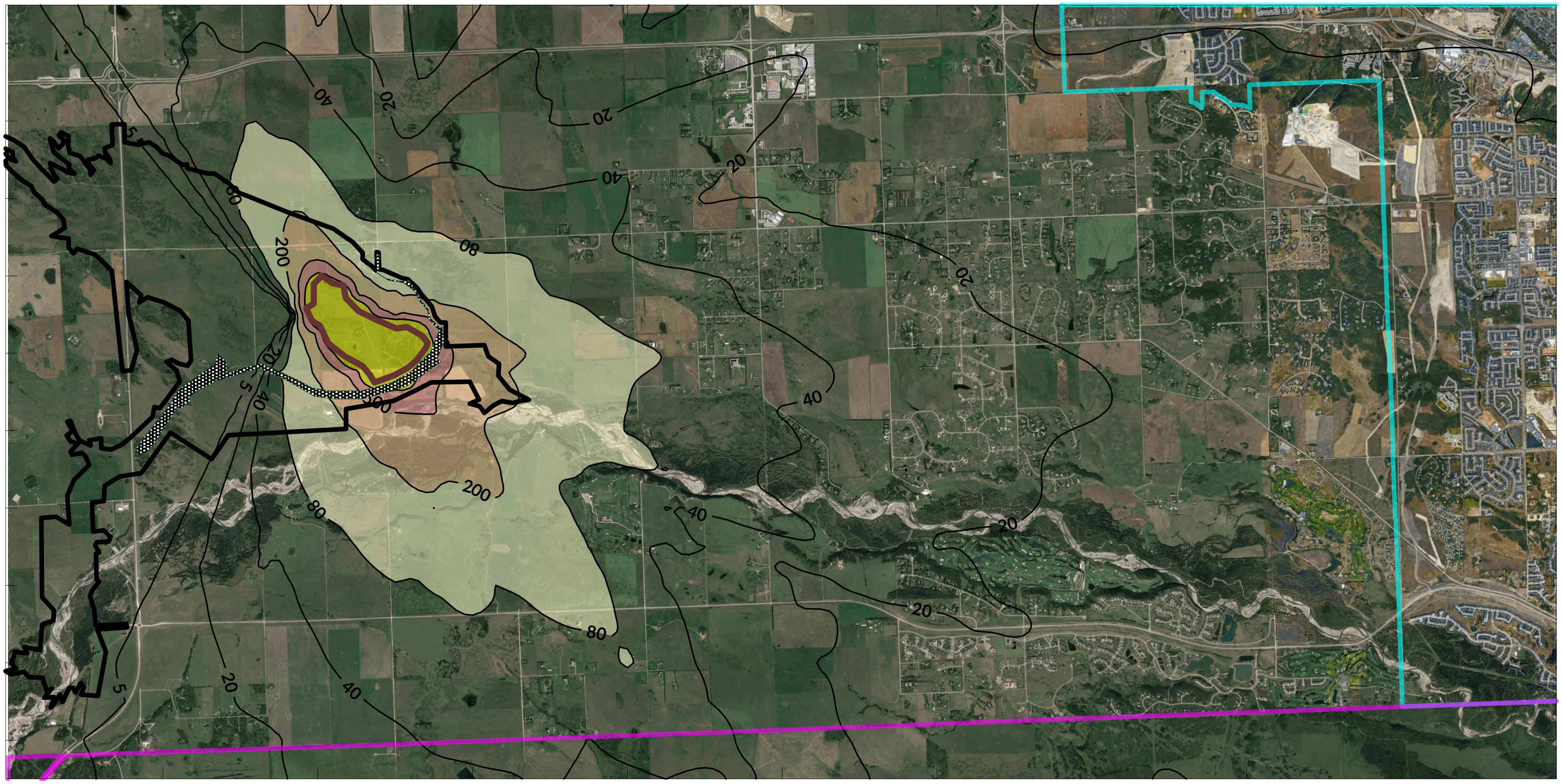
0 1000 2000 3000 4000 5000

NAD83 UTM 11, BASEMAP: GOOGLE EARTH

FILE: P:/2021/2100300-SPRINGBANKDAM/CALCS/AERMOD/S200/PM/P0999_PM25_TALLVEG.SRF

Re-Examination of Post Flood
Dry Reservoir Sediment Particulate Emissions
SPRINGBANK OFF-STREAM
RESERVOIR PROJECT

FIGURE A2:
Re-Run of 200yr flood
9th Highest (99.9th %)1h Average
Predicted PM2.5 Concentrations



LEGEND

- PROJECT AREA
- CALGARY CITY LIMITS (2018)
- FIRST NATIONS
- FLOODED AREA
- DEEP SEDIMENT (>10cm)

µg/m³: 0, 5, 20, 40, 80, 200, 500, 1000, 5000, 10000

EMISSION: $PM_{2.5}$
TIME AVERAGE: 1h Average (99.9th percentile)
MAXIMUM CONCENTRATION: 2925.9 µg/m³
OBJECTIVE: 80 µg/m³
BACKGROUND: 0 µg/m³
MODEL: AERMOD (18081)

N

Date: 18-Feb-2021

Zelt psi

Drawn By:

METRES

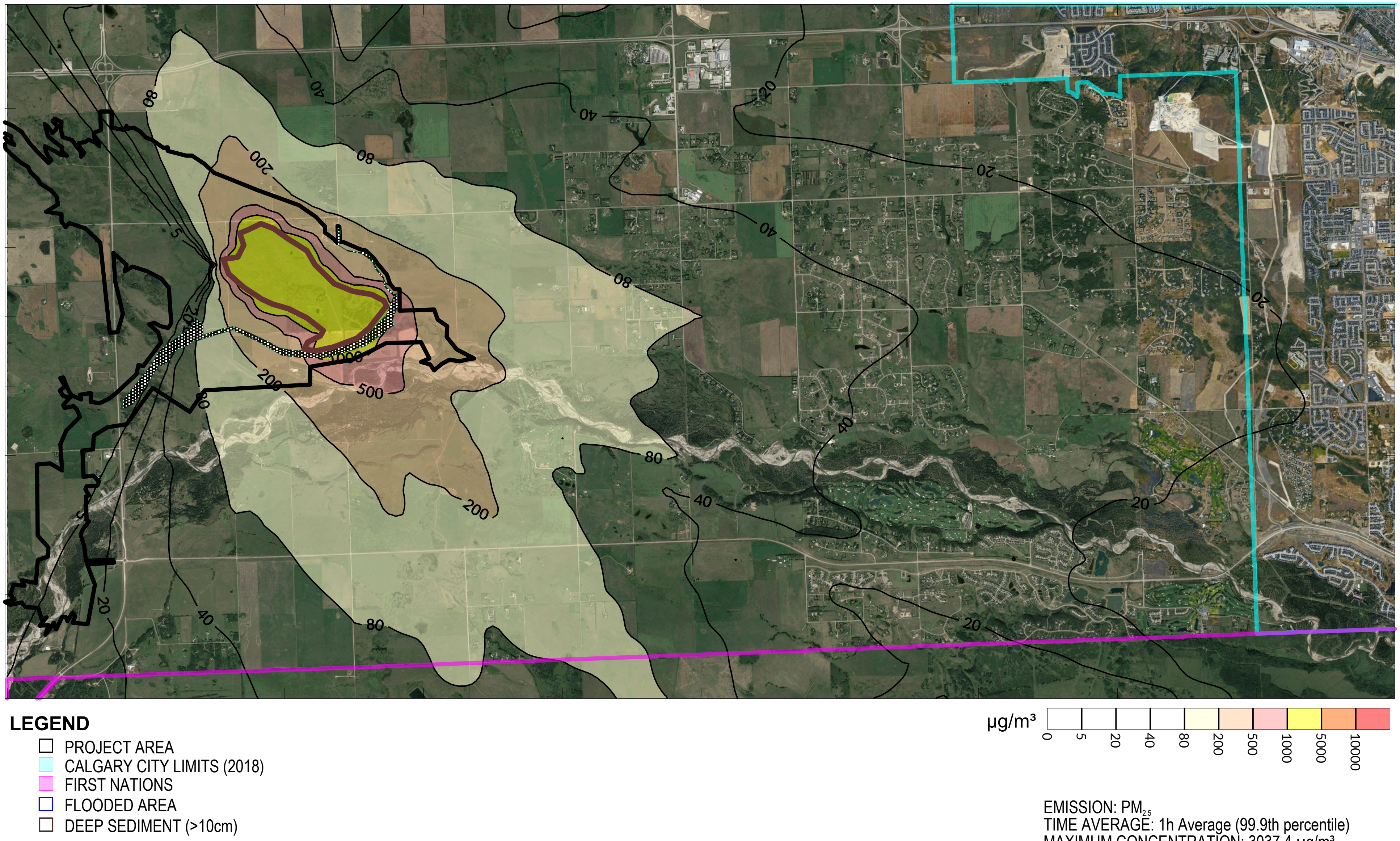
0 1000 2000 3000 4000 5000

NAD83 UTM 11, BASEMAP: GOOGLE EARTH

FILE: P:/2021/2100300-SPRINGBANKDAM/CALCS/AERMOD/S100A/PM/P0999_PM25_TALLVEG.SRF

Re-Examination of Post Flood Dry Reservoir Sediment Particulate Emissions SPRINGBANK OFF-STREAM RESERVOIR PROJECT

FIGURE A3:
Re-Evaluation of 100yr flood
9th Highest (99.9th %)1h Average
Predicted PM2.5 Concentrations



EMISSION: $PM_{2.5}$
TIME AVERAGE: 1h Average (99.9th percentile)
MAXIMUM CONCENTRATION: 3037.4 µg/m³
OBJECTIVE: 80 µg/m³
BACKGROUND: 0 µg/m³
MODEL: AERMOD (18081)

N

Date: 18-Feb-2021

Zelt psi

Drawn By:

METRES

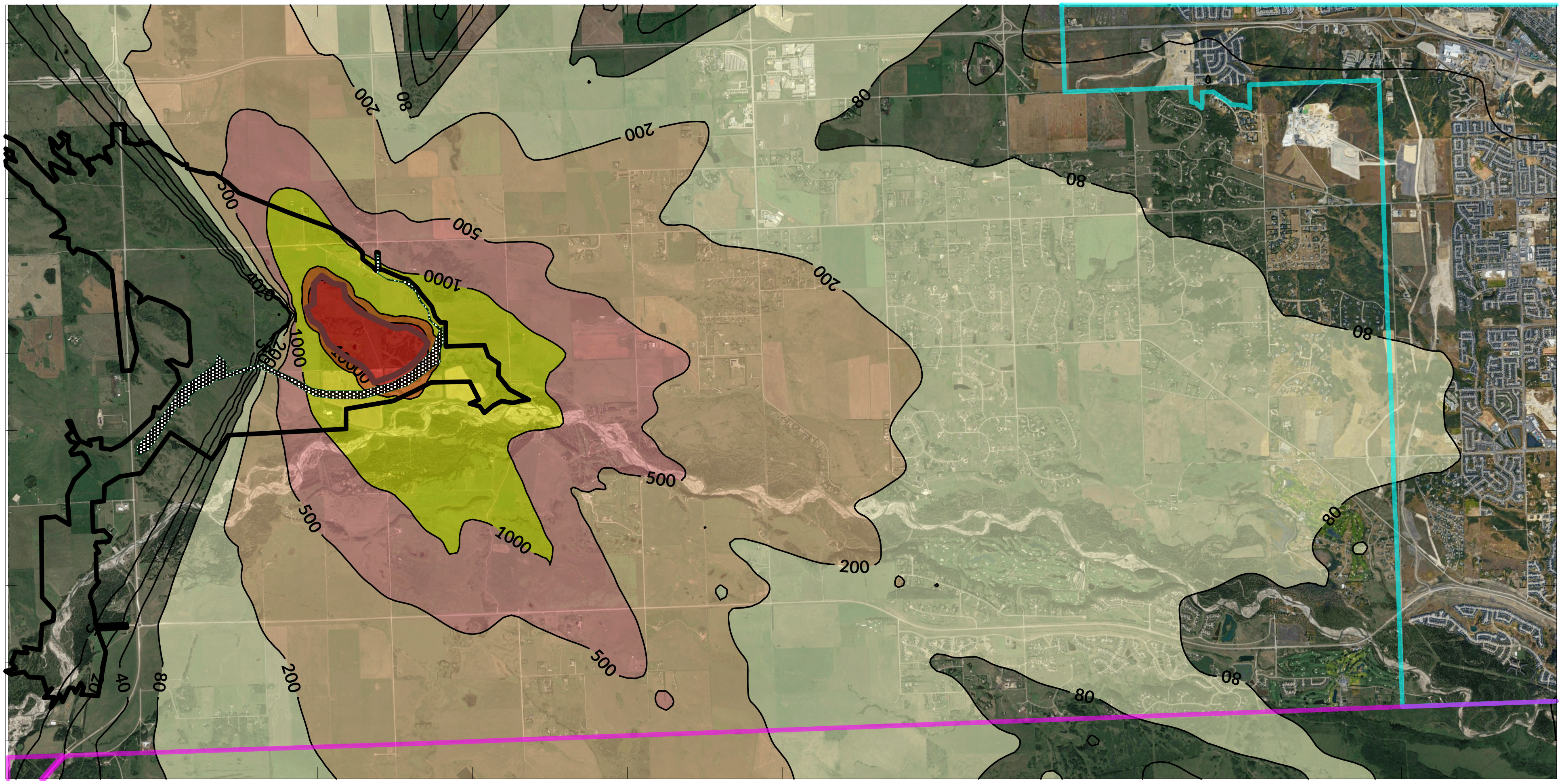
0 1000 2000 3000 4000 5000

NAD83 UTM 11, BASEMAP: GOOGLE EARTH

FILE: P:/2021/2100300-SPRINGBANKDAM/CALCS/AERMOD/S200A/PM/P0999_PM25_TALLVEG.SRF

Re-Examination of Post Flood
Dry Reservoir Sediment Particulate Emissions
SPRINGBANK OFF-STREAM
RESERVOIR PROJECT

FIGURE A4:
Re-Evaluation of 200yr flood
9th Highest (99.9th %)1h Average
Predicted PM2.5 Concentrations



LEGEND

- PROJECT AREA
- CALGARY CITY LIMITS (2018)
- FIRST NATIONS
- FLOODED AREA
- DEEP SEDIMENT (>10cm) COVERING LOW VEGETATION AREA

μg/m³: 0, 5, 20, 40, 80, 200, 500, 1000, 5000, 10000

EMISSION: $PM_{2.5}$
TIME AVERAGE: 1h Average (99.9th percentile)
MAXIMUM CONCENTRATION: 20895. μg/m³
OBJECTIVE: 80 μg/m³
BACKGROUND: 0 μg/m³
MODEL: AERMOD (18081)

N

Date: 18-Feb-2021

Zelt psi

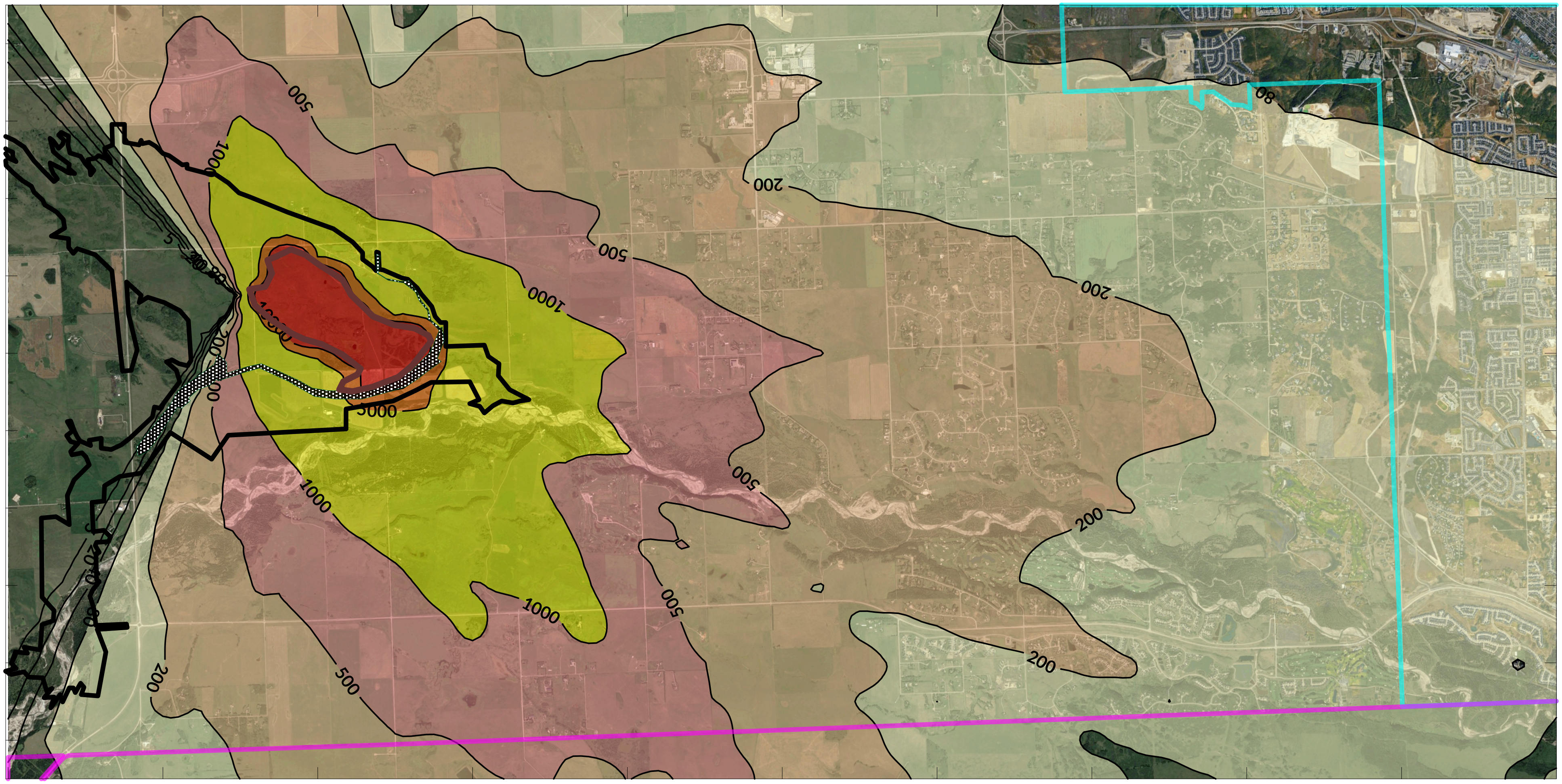
Drawn By:

METRES
0 1000 2000 3000 4000 5000

NAD83 UTM 11, BASEMAP: GOOGLE EARTH
FILE: P:/2021/2100300-SPRINGBANKDAM/CALCS/AERMOD/S100X/PM/P0999_PM25_TALLVEG.SRF

Re-Examination of Post Flood
Dry Reservoir Sediment Particulate Emissions
SPRINGBANK OFF-STREAM
RESERVOIR PROJECT

FIGURE A5:
Re-Evaluation of 100yr flood
9th Highest (99.9th %)1h Average
Predicted PM2.5 Concentrations
No Controls



LEGEND

- PROJECT AREA
- CALGARY CITY LIMITS (2018)
- FIRST NATIONS
- FLOODED AREA
- DEEP SEDIMENT (>10cm)

µg/m³: 0, 5, 20, 40, 80, 200, 500, 1000, 5000, 10000

EMISSION: $PM_{2.5}$
TIME AVERAGE: 1h Average (99.9th percentile)
MAXIMUM CONCENTRATION: 21691.2 µg/m³
OBJECTIVE: 80 µg/m³
BACKGROUND: 0 µg/m³
MODEL: AERMOD (18081)

N

Date: 18-Feb-2021

Zelt psi

Drawn By:

METRES

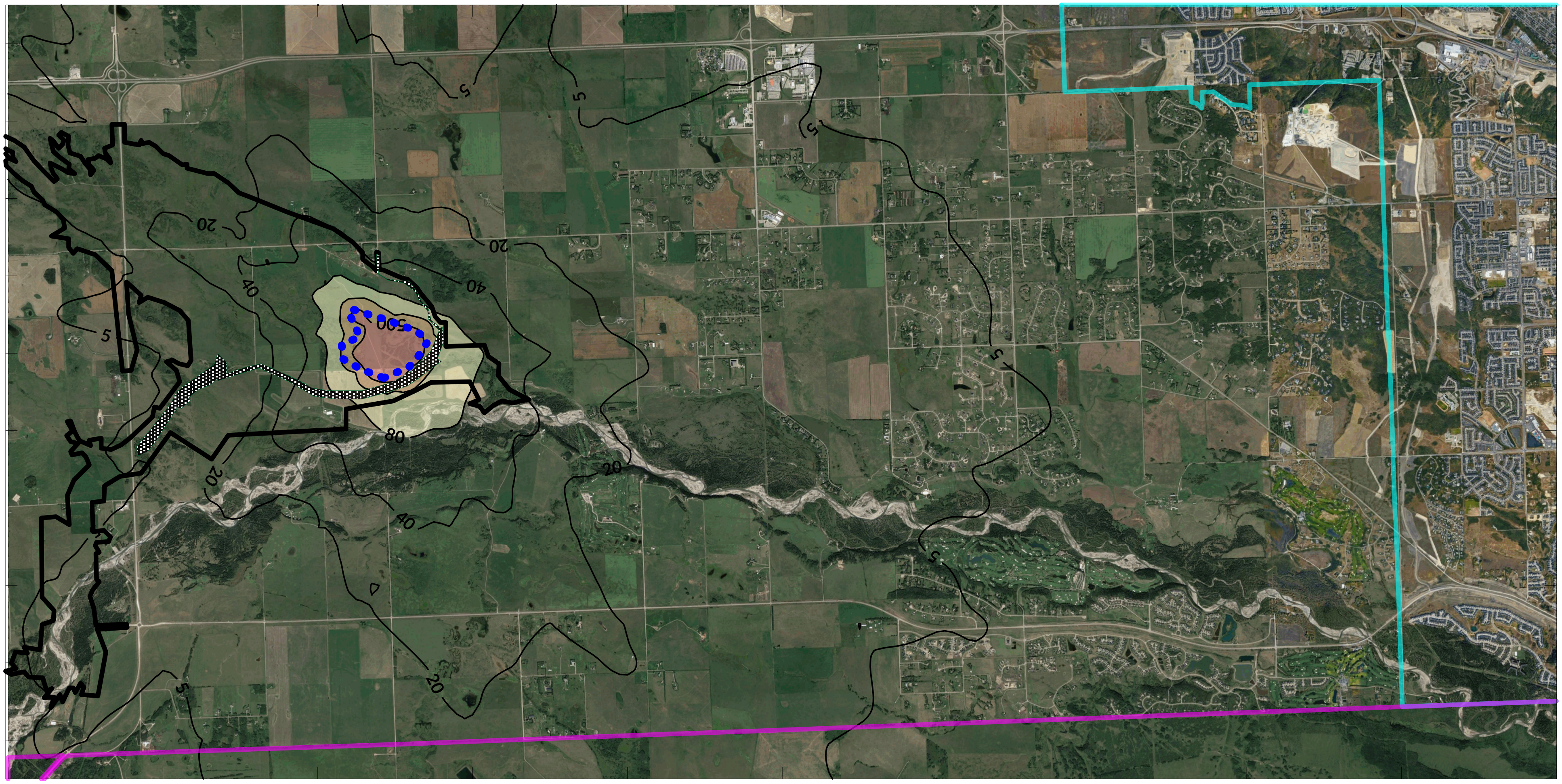
0 1000 2000 3000 4000 5000

NAD83 UTM 11, BASEMAP: GOOGLE EARTH

FILE: P:/2021/2100300-SPRINGBANKDAM/CALCS/AERMOD/S200X/PM/P0999_PM25_TALLVEG.SRF

Re-Examination of Post Flood
Dry Reservoir Sediment Particulate Emissions
SPRINGBANK OFF-STREAM
RESERVOIR PROJECT

FIGURE A6:
Re-Evaluation of 200yr flood
9th Highest (99.9th %)1h Average
Predicted PM2.5 Concentrations
No Controls



LEGEND

- PROJECT AREA
- CALGARY CITY LIMITS (2018)
- FIRST NATIONS
- FLOODED AREA
- DEEP SEDIMENT (>10cm)

µg/m³: 0, 5, 20, 40, 80, 200, 500, 1000, 5000, 10000

EMISSION: $PM_{2.5}$
TIME AVERAGE: 1h Average (99.9th percentile)
MAXIMUM CONCENTRATION: 804. µg/m³
OBJECTIVE: 80 µg/m³
BACKGROUND: 0 µg/m³
MODEL: AERMOD (18081)

N

Date: 18-Feb-2021

Zelt psi

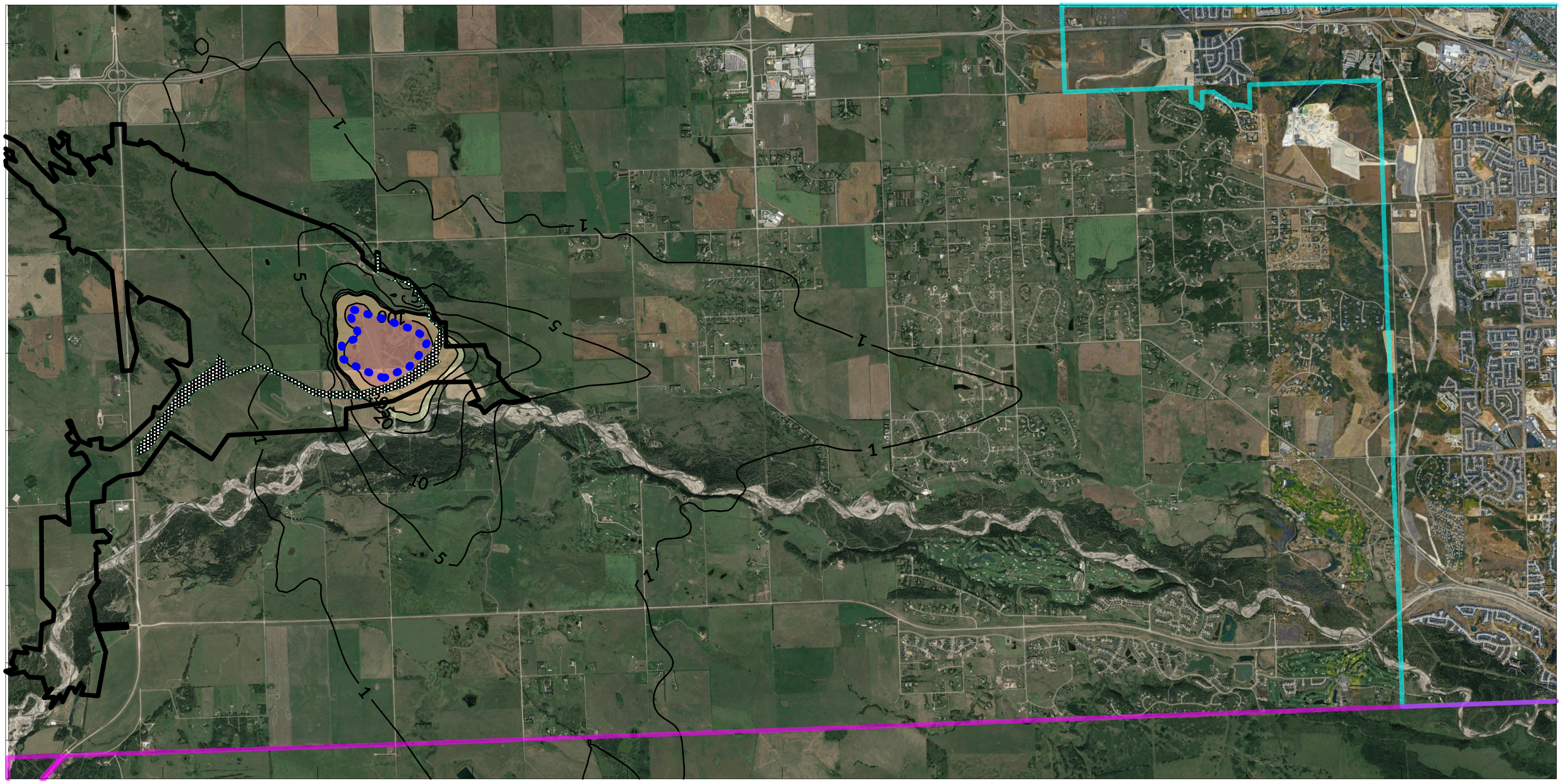
Drawn By:

METRES
0 1000 2000 3000 4000 5000

NAD83 UTM 11, BASEMAP: GOOGLE EARTH
FILE: P:/2021/2100300-SPRINGBANKDAM/CALCS/AERMOD/Y10/PM/P0999_PM25_TALLVEG.SRF

Re-Examination of Post Flood Dry Reservoir Sediment Particulate Emissions SPRINGBANK OFF-STREAM RESERVOIR PROJECT

FIGURE A7.1:
10yr flood
9th Highest (99.9th %)1h Average
Predicted PM2.5 Concentrations
Including Flooded Area With Silted Vegetation Areas



LEGEND

- PROJECT AREA
- CALGARY CITY LIMITS (2018)
- FIRST NATIONS
- FLOODED AREA
- DEEP SEDIMENT (>10cm)

µg/m³ 0 1 5 10 20 25 30 100 500 1000 2000

EMISSION: $PM_{2.5}$
TIME AVERAGE: 1h Average (99.9th percentile)
MAXIMUM CONCENTRATION: 377.6 µg/m³
OBJECTIVE: 30 µg/m³
BACKGROUND: 0 µg/m³
MODEL: AERMOD (18081)

N

Date: 18-Feb-2021

Zelt psi

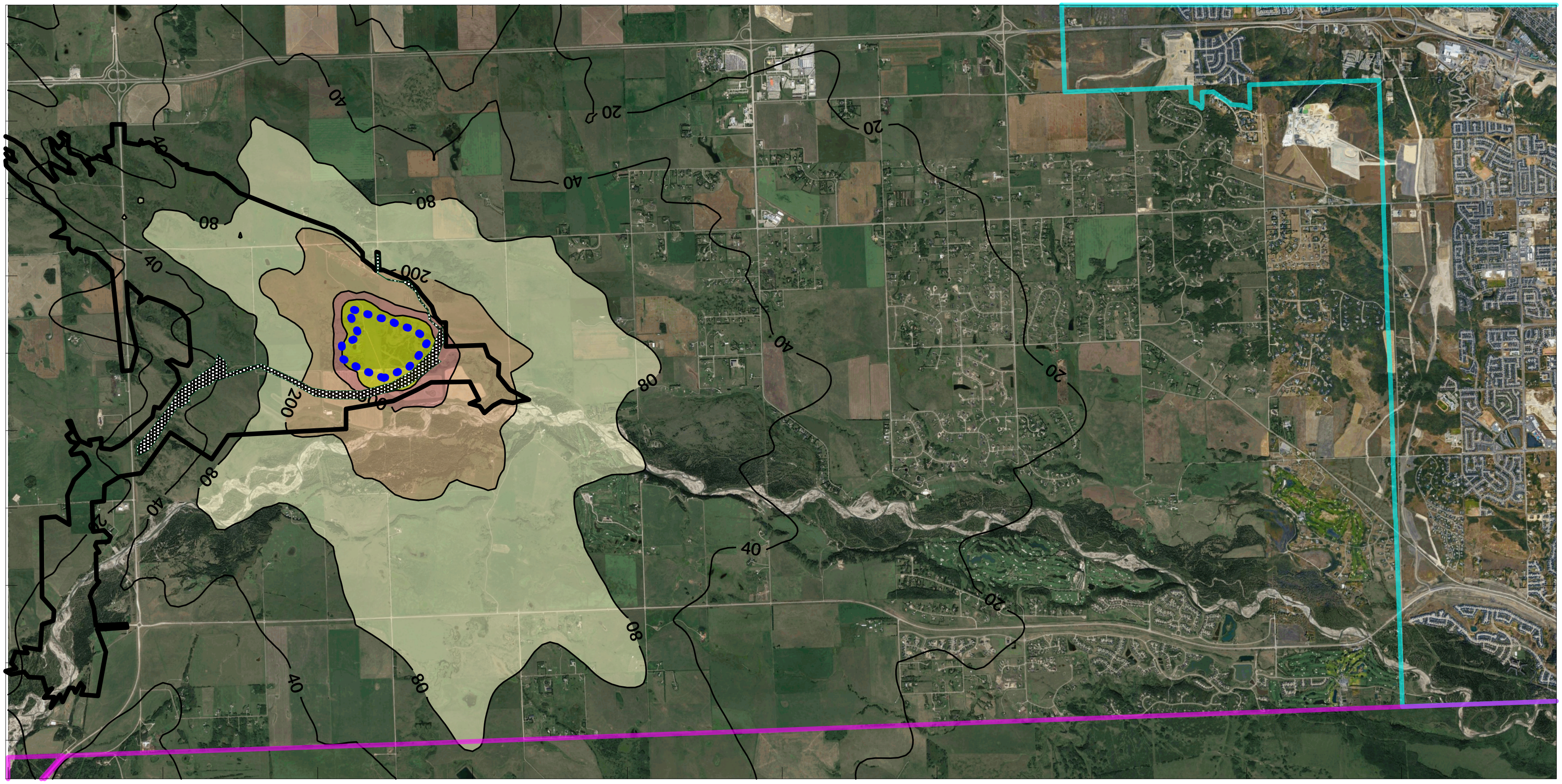
Drawn By:

METRES
0 1000 2000 3000 4000 5000

NAD83 UTM 11, BASEMAP: GOOGLE EARTH
FILE: P:/2021/2100300-SPRINGBANKDAM/CALCS/AERMOD/Y10/PM/PD098_PM25_TALLVEG.SRF

Re-Examination of Post Flood
Dry Reservoir Sediment Particulate Emissions
SPRINGBANK OFF-STREAM
RESERVOIR PROJECT

FIGURE A7.2:
10yr flood
98th% 24h Average
Predicted PM2.5 Concentrations
Including Flooded Area With Silted Vegetation Areas



LEGEND

- PROJECT AREA
- CALGARY CITY LIMITS (2018)
- FIRST NATIONS
- FLOODED AREA
- DEEP SEDIMENT (>10cm)

µg/m³: 0, 5, 20, 40, 80, 200, 500, 1000, 5000, 10000

EMISSION: $PM_{2.5}$
TIME AVERAGE: 1h Average (99.9th percentile)
MAXIMUM CONCENTRATION: 3495.8 µg/m³
OBJECTIVE: None µg/m³
BACKGROUND: 0 µg/m³
MODEL: AERMOD (18081)

N

Date: 18-Feb-2021

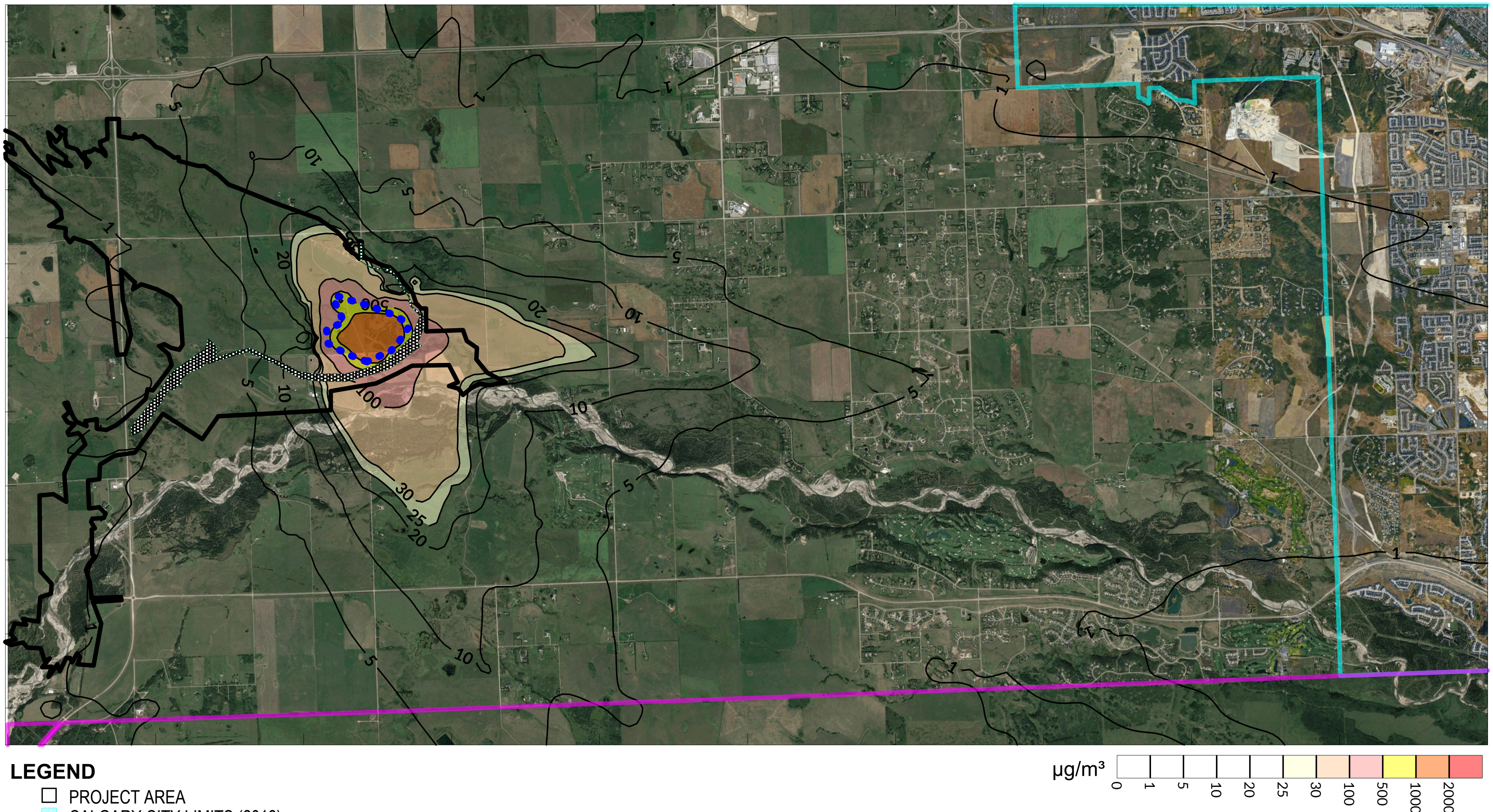
Drawn By:

METRES
0 1000 2000 3000 4000 5000

NAD83 UTM 11, BASEMAP: GOOGLE EARTH
FILE: P:/2021/2100300-SPRINGBANKDAM/CALCS/AERMOD/Y10/PM/P0999_TSP_TALLVEG.SRF

Re-Examination of Post Flood Dry Reservoir Sediment Particulate Emissions SPRINGBANK OFF-STREAM RESERVOIR PROJECT

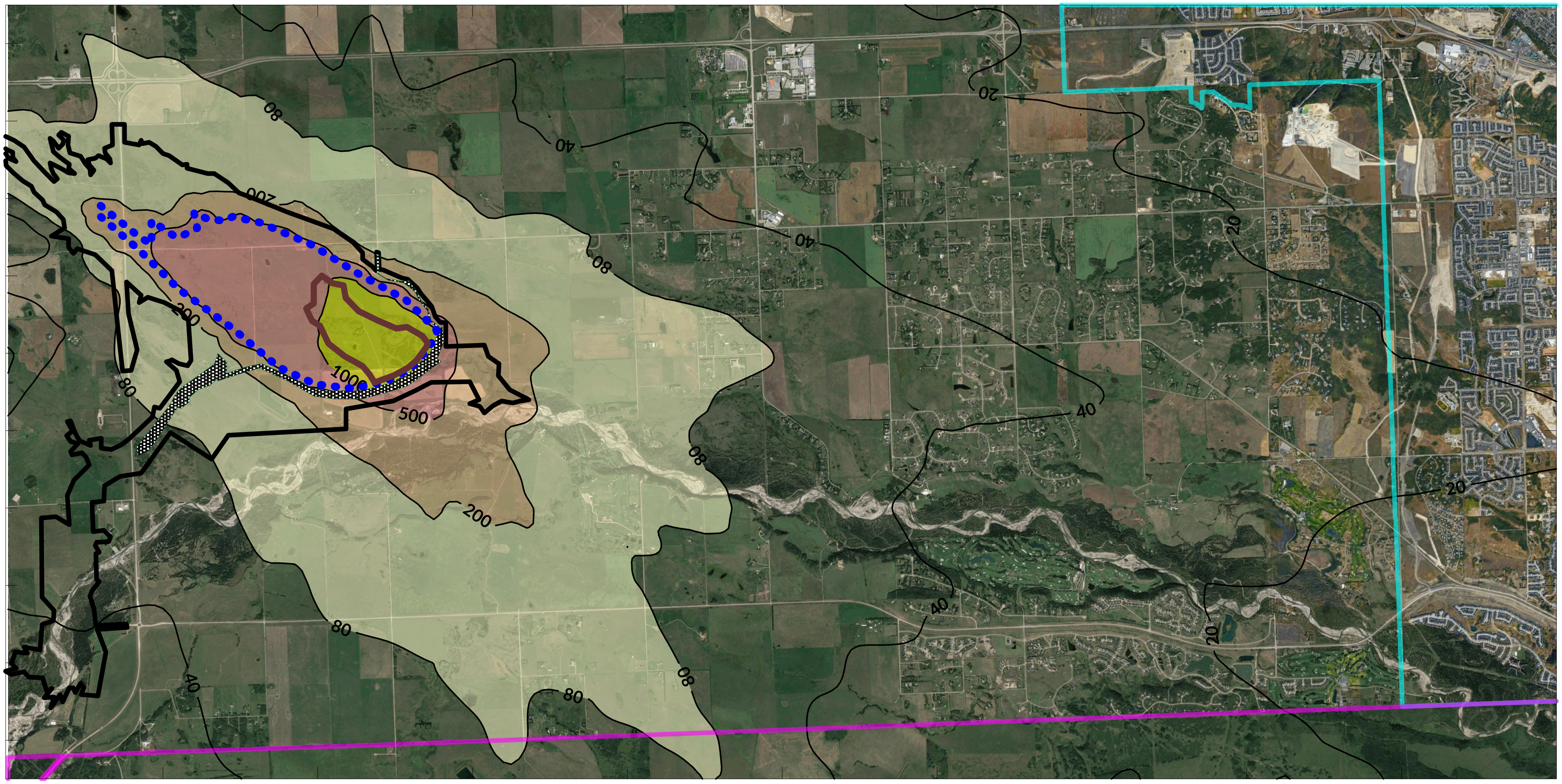
FIGURE A7.3:
10yr flood
9th Highest (99.9th %)1h Average
Predicted TSP Concentrations
Including Flooded Area With Silted Vegetation Areas



LEGEND
- PROJECT AREA
- CALGARY CITY LIMITS (2018)
- FIRST NATIONS
- FLOODED AREA
- DEEP SEDIMENT (>10cm)

EMISSION: $PM_{2.5}$
TIME AVERAGE: 1h Average (99.9th percentile)
MAXIMUM CONCENTRATION: 1641.6 µg/m³
OBJECTIVE: 100 µg/m³
BACKGROUND: 0 µg/m³
MODEL: AERMOD (18081)

Date: 18-Feb-2021 Drawn By: Zelt psi METRES 0 1000 2000 3000 4000 5000 NAD83 UTM 11, BASEMAP: GOOGLE EARTH FILE: P:/2021/2100300-SPRINGBANKDAM/CALCS/AERMOD/Y10/PM/PD098_TSP_TALLVEG.SRF	**Re-Examination of Post Flood Dry Reservoir Sediment Particulate Emissions SPRINGBANK OFF-STREAM RESERVOIR PROJECT**	**FIGURE A7.4:** **10yr flood** **98th% 24h Average** **Predicted TSP Concentrations** **Including Flooded Area With Silted Vegetation Areas**



LEGEND

- PROJECT AREA
- CALGARY CITY LIMITS (2018)
- FIRST NATIONS
- FLOODED AREA
- DEEP SEDIMENT (>10cm)

EMISSION: $PM_{2.5}$
TIME AVERAGE: 1h Average (99.9th percentile)
MAXIMUM CONCENTRATION: 2869.2 µg/m³
OBJECTIVE: 80 µg/m³
BACKGROUND: 0 µg/m³
MODEL: AERMOD (18081)

N

Date: 18-Feb-2021

Zelt psi

Drawn By:

METRES

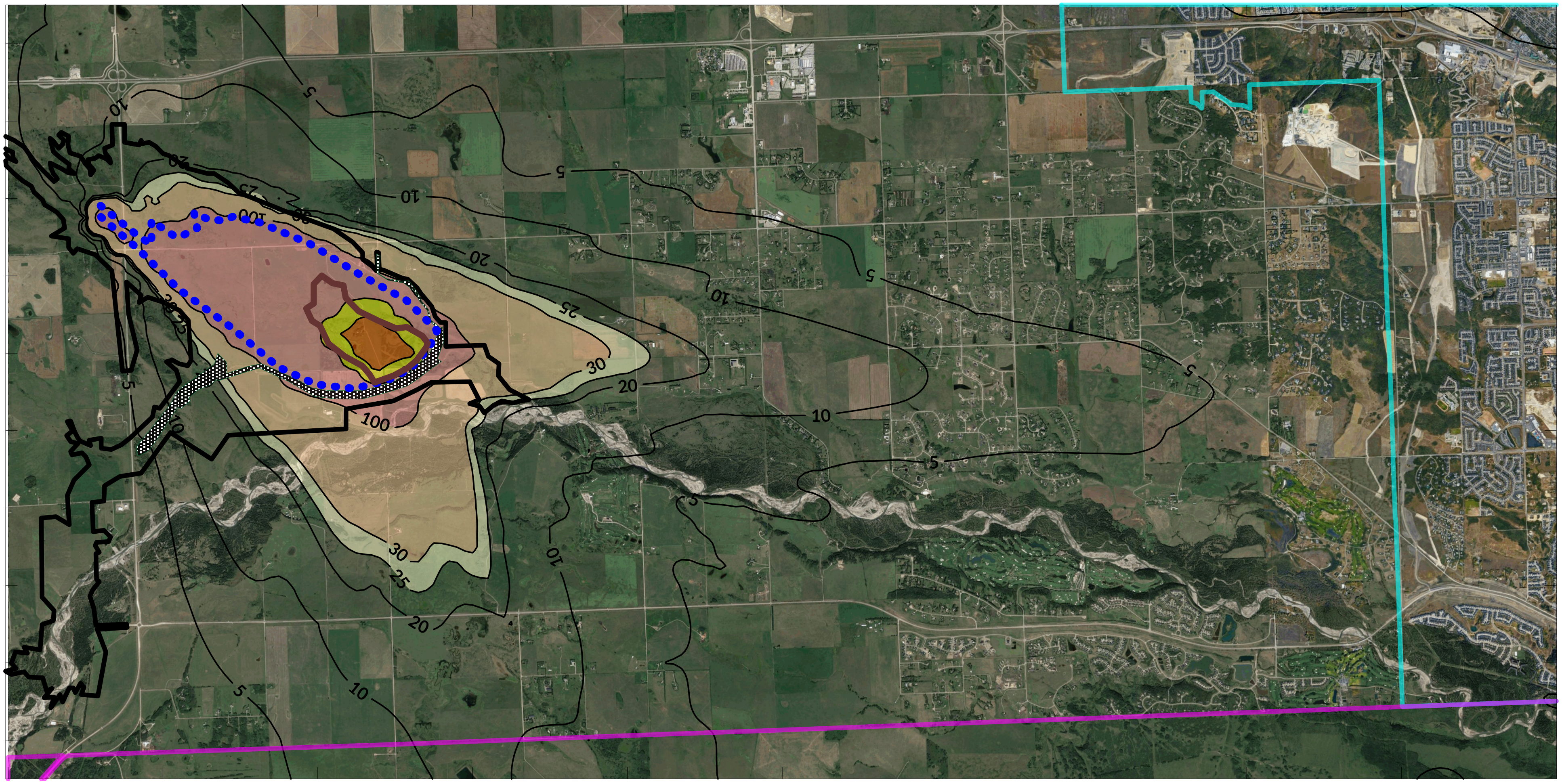
0 1000 2000 3000 4000 5000

NAD83 UTM 11, BASEMAP: GOOGLE EARTH

FILE: P:/2021/2100300-SPRINGBANKDAM/CALCS/AERMOD/Y100/PM/P0999_PM25_TALLVEG.SRF

Re-Examination of Post Flood Dry Reservoir Sediment Particulate Emissions SPRINGBANK OFF-STREAM RESERVOIR PROJECT

FIGURE A8.1:
100yr flood
9th Highest (99.9th %)1h Average
Predicted PM2.5 Concentrations
Including Flooded Area With Silted Vegetation Areas



LEGEND

- PROJECT AREA
- CALGARY CITY LIMITS (2018)
- FIRST NATIONS
- FLOODED AREA
- DEEP SEDIMENT (>10cm)

µg/m³: 0, 1, 5, 10, 20, 25, 30, 100, 500, 1000, 2000

EMISSION: $PM_{2.5}$
TIME AVERAGE: 1h Average (99.9th percentile)
MAXIMUM CONCENTRATION: 1197.7 µg/m³
OBJECTIVE: 30 µg/m³
BACKGROUND: 0 µg/m³
MODEL: AERMOD (18081)

N

Date: 18-Feb-2021

Zelt psi

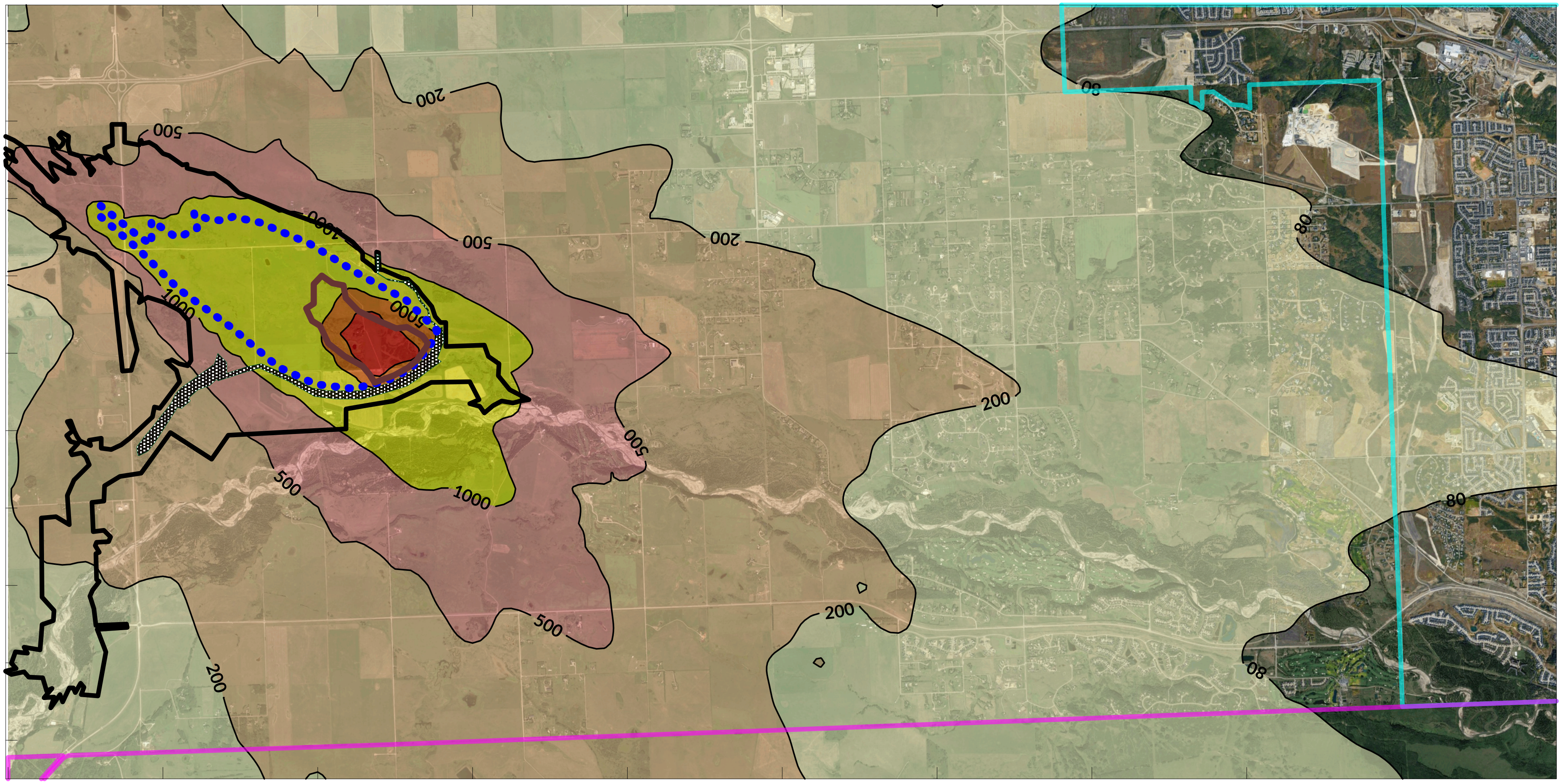
Drawn By:

METRES
0 1000 2000 3000 4000 5000

NAD83 UTM 11, BASEMAP: GOOGLE EARTH
FILE: P:/2021/2100300-SPRINGBANKDAM/CALCS/AERMOD/Y100/PM/PD098_PM25_TALLVEG.SRF

Re-Examination of Post Flood
Dry Reservoir Sediment Particulate Emissions
SPRINGBANK OFF-STREAM
RESERVOIR PROJECT

FIGURE A8.2:
100yr flood
98th% 24h Average
Predicted PM2.5 Concentrations
Including Flooded Area With Silted Vegetation Areas



LEGEND

- PROJECT AREA
- CALGARY CITY LIMITS (2018)
- FIRST NATIONS
- FLOODED AREA
- DEEP SEDIMENT (>10cm)

µg/m³

0 5 20 40 80 200 500 1000 5000 10000

EMISSION: $PM_{2.5}$
TIME AVERAGE: 1h Average (99.9th percentile)
MAXIMUM CONCENTRATION: 12474.6 µg/m³
OBJECTIVE: None µg/m³
BACKGROUND: 0 µg/m³
MODEL: AERMOD (18081)

N

Date: 18-Feb-2021

Drawn By:

METRES

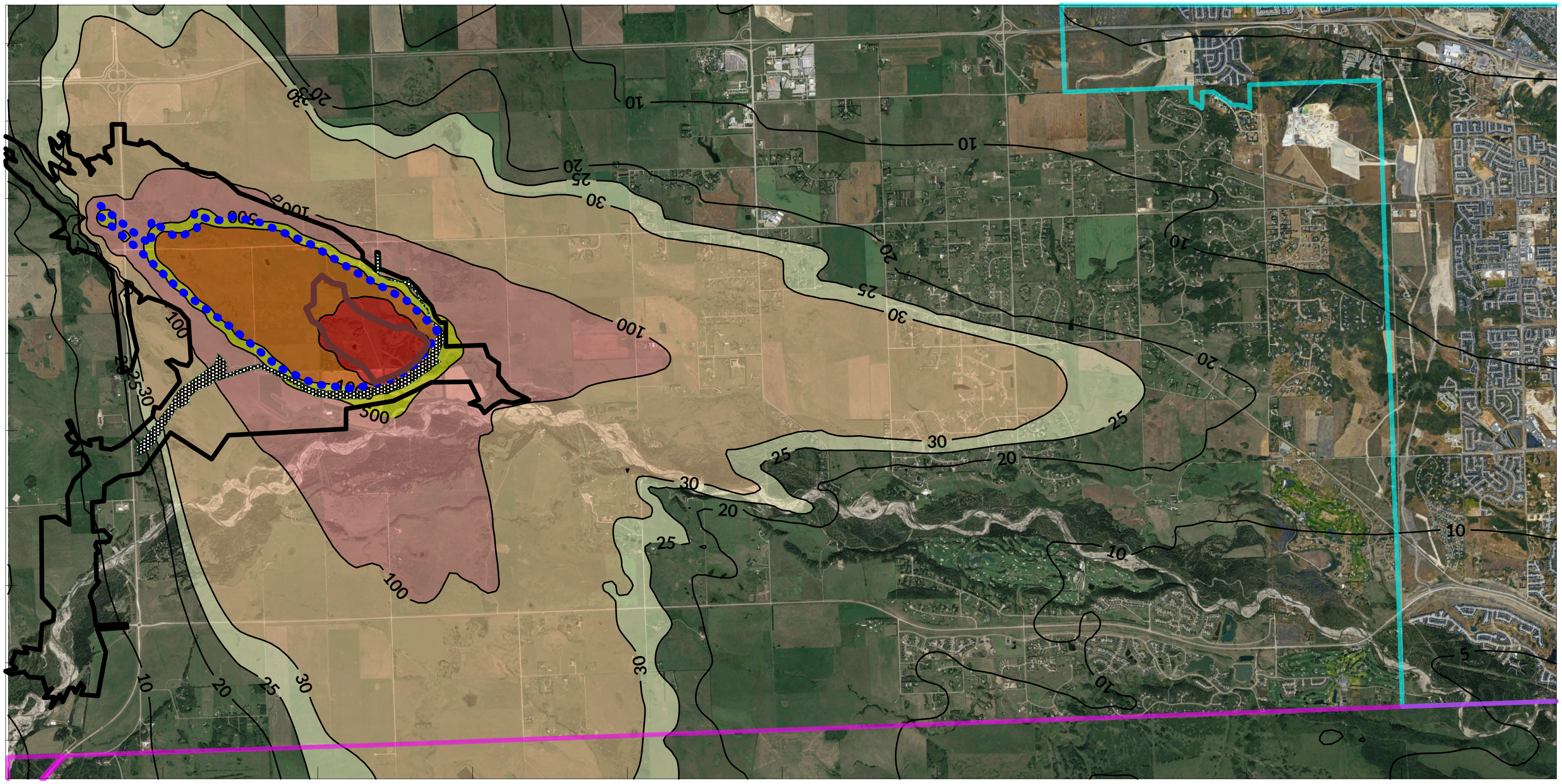
0 1000 2000 3000 4000 5000

NAD83 UTM 11, BASEMAP: GOOGLE EARTH

FILE: P:/2021/2100300-SPRINGBANKDAM/CALCS/AERMOD/Y100/PM/P0999_TSP_TALLVEG.SRF

Re-Examination of Post Flood Dry Reservoir Sediment Particulate Emissions SPRINGBANK OFF-STREAM RESERVOIR PROJECT

FIGURE A8.3:
100yr flood
9th Highest (99.9th %)1h Average
Predicted TSP Concentrations
Including Flooded Area With Silted Vegetation Areas



LEGEND

- PROJECT AREA
- CALGARY CITY LIMITS (2018)
- FIRST NATIONS
- FLOODED AREA
- DEEP SEDIMENT (>10cm)

µg/m³: 0, 1, 5, 10, 20, 25, 30, 100, 500, 1000, 2000

EMISSION: $PM_{2.5}$
TIME AVERAGE: 1h Average (99.9th percentile)
MAXIMUM CONCENTRATION: 5207.3 µg/m³
OBJECTIVE: 100 µg/m³
BACKGROUND: 0 µg/m³
MODEL: AERMOD (18081)

N

Date: 18-Feb-2021

Zelt psi

Drawn By:

METRES

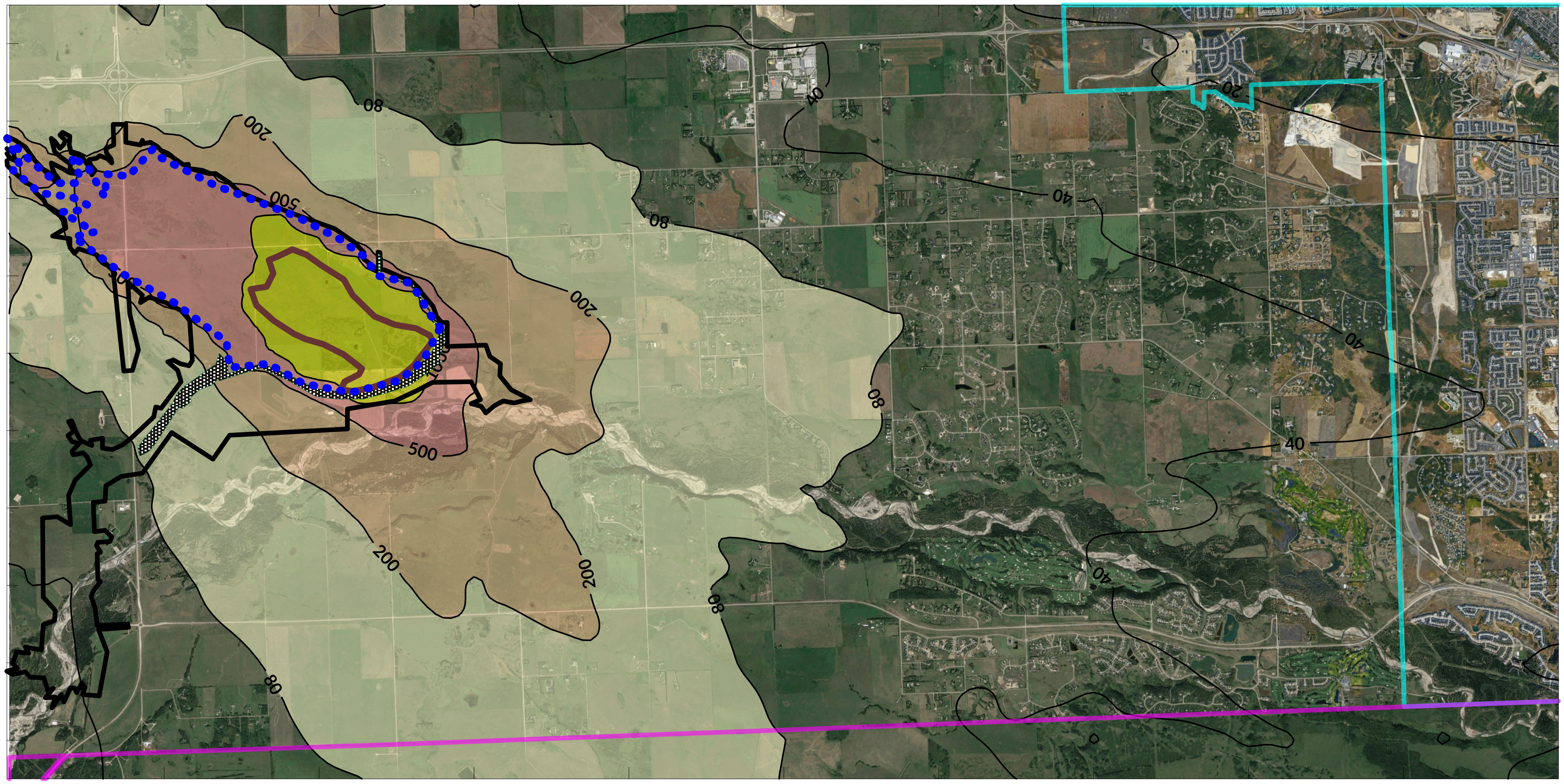
0 1000 2000 3000 4000 5000

NAD83 UTM 11, BASEMAP: GOOGLE EARTH

FILE: P:/2021/2100300-SPRINGBANKDAM/CALCS/AERMOD/Y100/PM/PD098_TSP_TALLVEG.SRF

Re-Examination of Post Flood Dry Reservoir Sediment Particulate Emissions SPRINGBANK OFF-STREAM RESERVOIR PROJECT

FIGURE A8.4:
100yr flood
98th% 24h Average
Predicted TSP Concentrations
Including Flooded Area With Silted Vegetation Areas



LEGEND

- PROJECT AREA
- CALGARY CITY LIMITS (2018)
- FIRST NATIONS
- FLOODED AREA
- DEEP SEDIMENT (>10cm)

μg/m³: 0, 5, 20, 40, 80, 200, 500, 1000, 5000, 10000

EMISSION: $PM_{2.5}$
TIME AVERAGE: 1h Average (99.9th percentile)
MAXIMUM CONCENTRATION: 3081.2 μg/m³
OBJECTIVE: 80 μg/m³
BACKGROUND: 0 μg/m³
MODEL: AERMOD (18081)

N

Date: 18-Feb-2021

Drawn By:

METRES

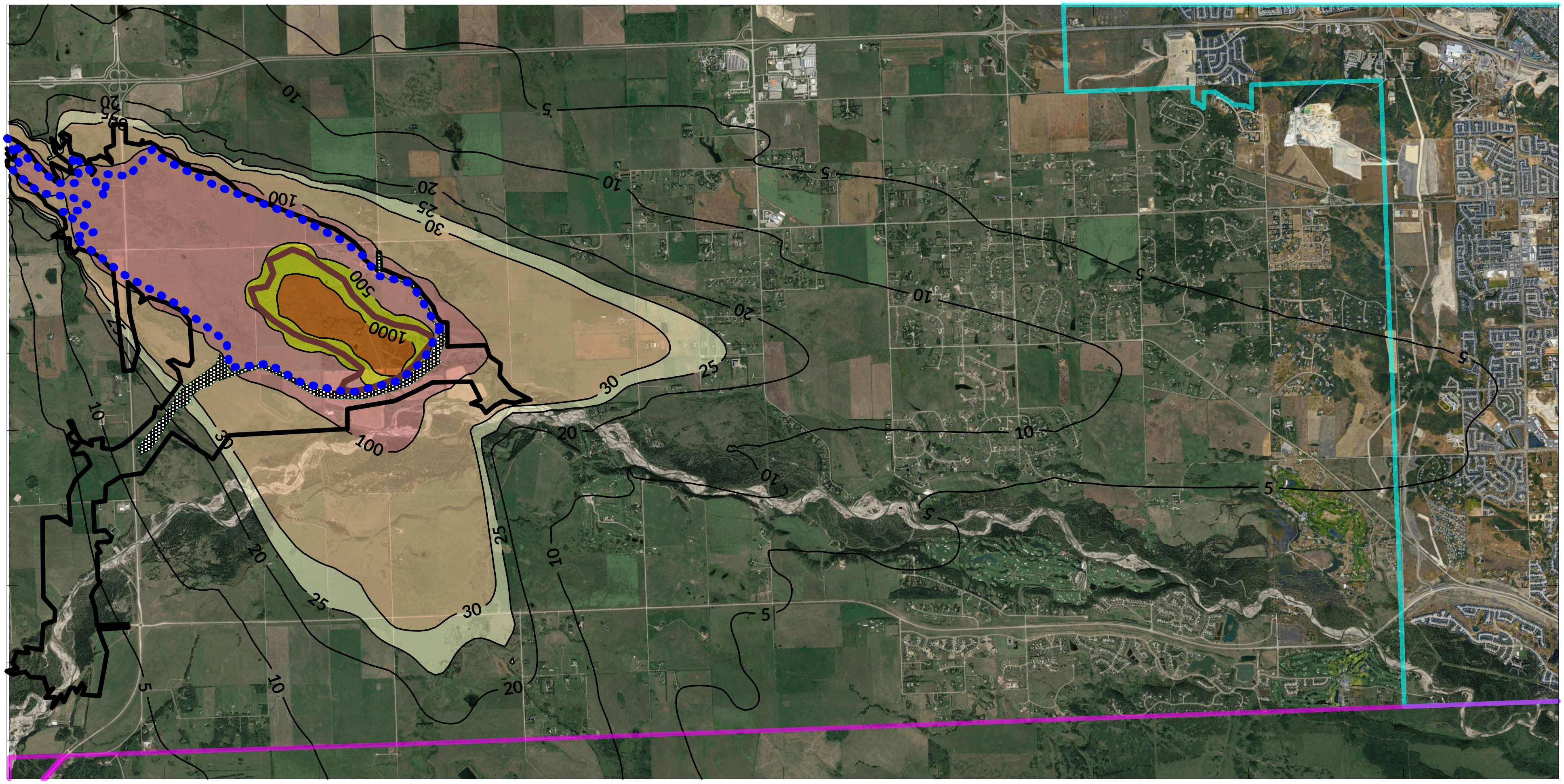
0 1000 2000 3000 4000 5000

NAD83 UTM 11, BASEMAP: GOOGLE EARTH

FILE: P:/2021/2100300-SPRINGBANKDAM/CALCS/AERMOD/Y2013/PM/P0999_PM25_TALLVEG.SRF

Re-Examination of Post Flood Dry Reservoir Sediment Particulate Emissions SPRINGBANK OFF-STREAM RESERVOIR PROJECT

FIGURE A9.1:
200yr (2013) flood
9th Highest (99.9th %)1h Average
Predicted PM2.5 Concentrations
Including Flooded Area With Silted Vegetation Areas



LEGEND

- PROJECT AREA
- CALGARY CITY LIMITS (2018)
- FIRST NATIONS
- FLOODED AREA
- DEEP SEDIMENT (>10cm)

µg/m³: 0, 1, 5, 10, 20, 25, 30, 100, 500, 1000, 2000

EMISSION: $PM_{2.5}$
TIME AVERAGE: 1h Average (99.9th percentile)
MAXIMUM CONCENTRATION: 1190.2 µg/m³
OBJECTIVE: 30 µg/m³
BACKGROUND: 0 µg/m³
MODEL: AERMOD (18081)

N

Date: 18-Feb-2021

Zelt psi

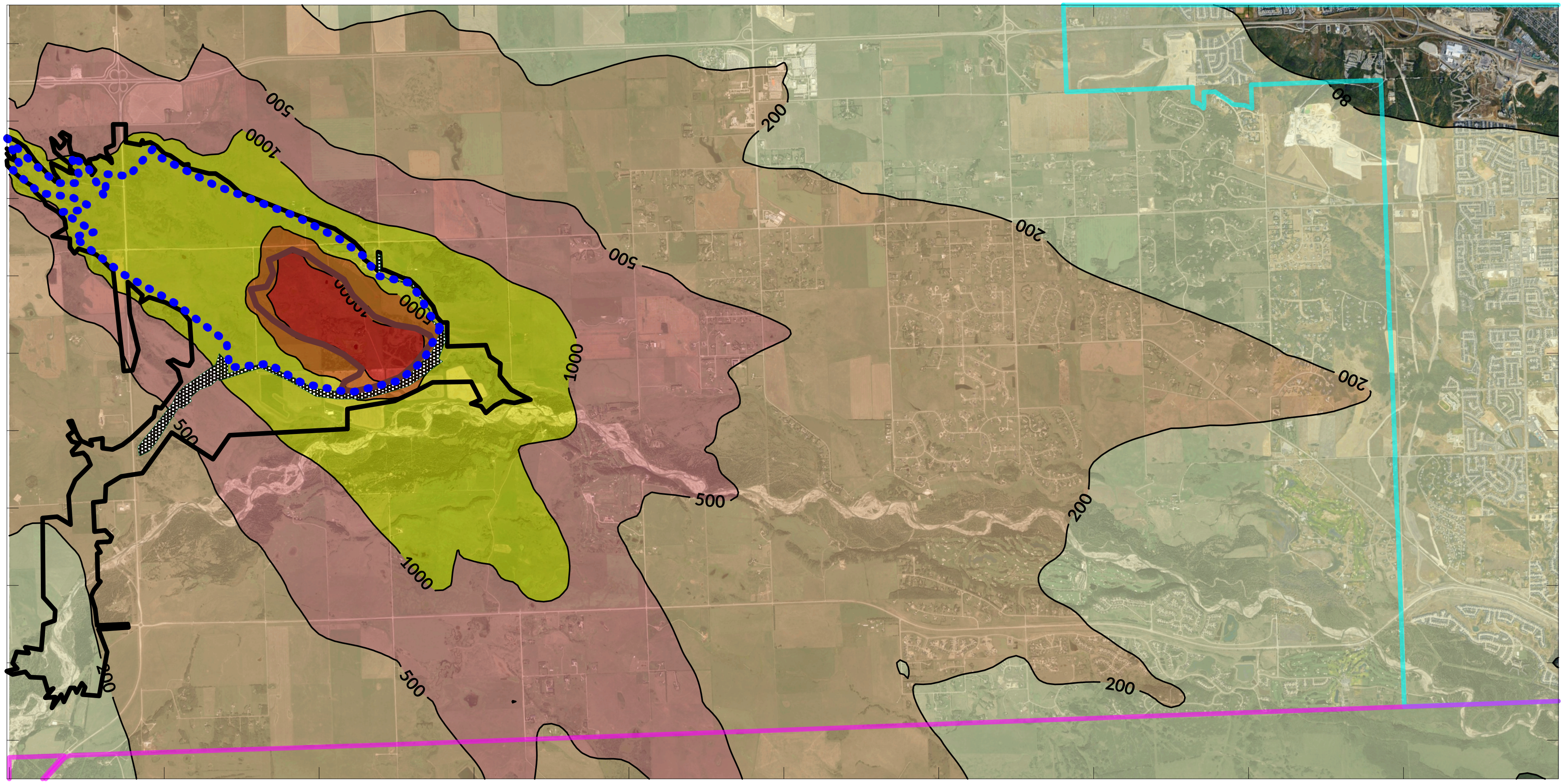
Drawn By:

METRES
0 1000 2000 3000 4000 5000

NAD83 UTM 11, BASEMAP: GOOGLE EARTH
FILE: P:/2021/2100300-SPRINGBANKDAM/CALCS/AERMOD/Y2013/PM/PD098_PM25_TALLVEG.SRF

Re-Examination of Post Flood Dry Reservoir Sediment Particulate Emissions SPRINGBANK OFF-STREAM RESERVOIR PROJECT

FIGURE A9.2:
200yr (2013) flood
98th% 24h Average
Predicted PM2.5 Concentrations
Including Flooded Area With Silted Vegetation Areas



LEGEND

- PROJECT AREA
- CALGARY CITY LIMITS (2018)
- FIRST NATIONS
- FLOODED AREA
- DEEP SEDIMENT (>10cm)

µg/m³

0	5	20	40	80	200	500	1000	5000	10000

EMISSION: $PM_{2.5}$
TIME AVERAGE: 1h Average (99.9th percentile)
MAXIMUM CONCENTRATION: 13396.4 µg/m³
OBJECTIVE: None µg/m³
BACKGROUND: 0 µg/m³
MODEL: AERMOD (18081)

N

Date:
18-Feb-2021

Zelt psi

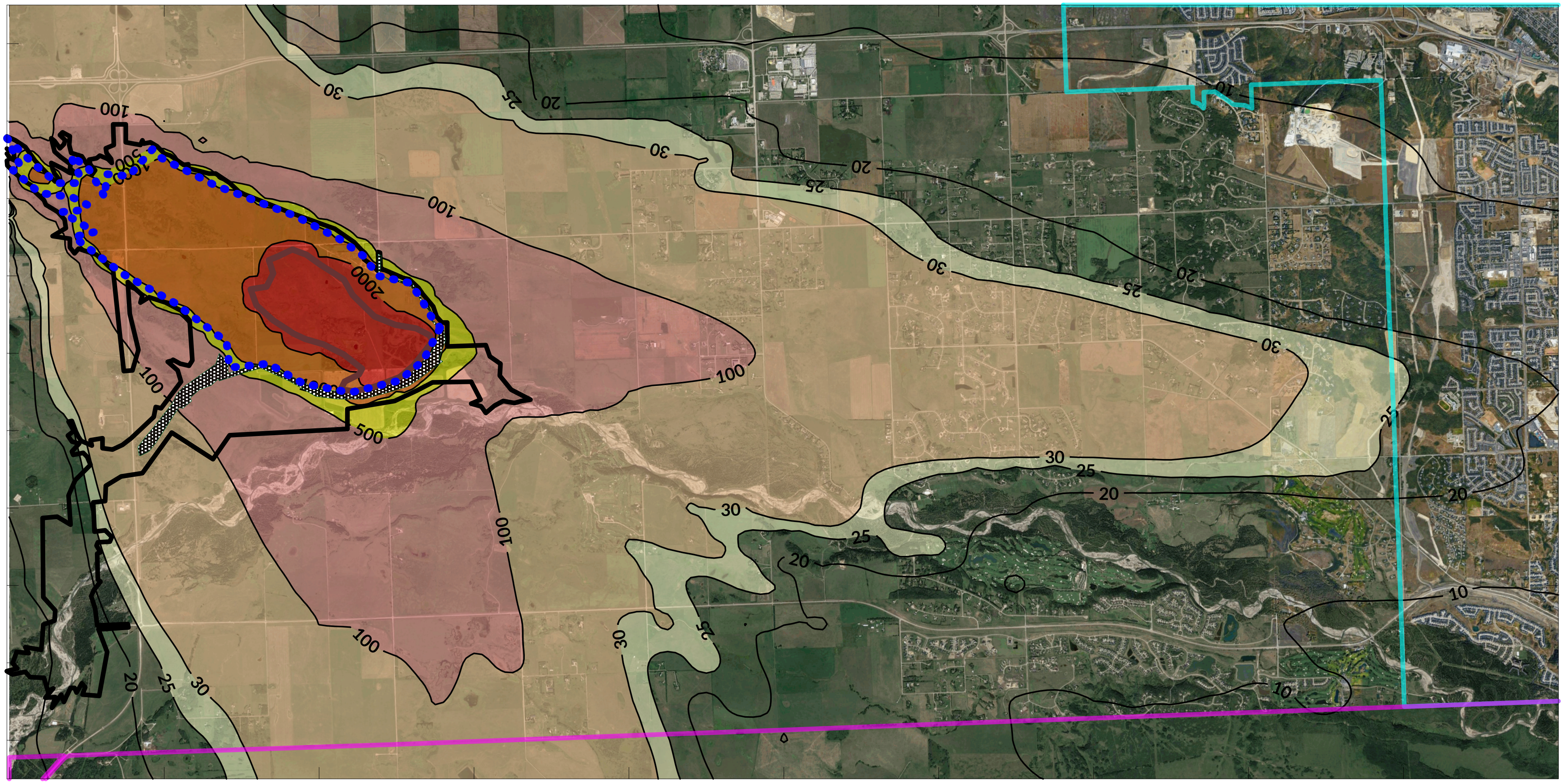
Drawn By:

METRES
0 1000 2000 3000 4000 5000

NAD83 UTM 11, BASEMAP: GOOGLE EARTH
FILE: P:/2021/2100300-SPRINGBANKDAM/CALCS/AERMOD/Y2013/PM/P0999_TSP_TALLVEG.SRF

Re-Examination of Post Flood
Dry Reservoir Sediment Particulate Emissions
SPRINGBANK OFF-STREAM
RESERVOIR PROJECT

FIGURE A9.3:
200yr (2013) flood
9th Highest (99.9th %)1h Average
Predicted TSP Concentrations
Including Flooded Area With Silted Vegetation Areas



LEGEND

- PROJECT AREA
- CALGARY CITY LIMITS (2018)
- FIRST NATIONS
- FLOODED AREA
- DEEP SEDIMENT (>10cm)

EMISSION: $PM_{2.5}$
TIME AVERAGE: 1h Average (99.9th percentile)
MAXIMUM CONCENTRATION: 5174.8 µg/m³
OBJECTIVE: 100 µg/m³
BACKGROUND: 0 µg/m³
MODEL: AERMOD (18081)

N

Date: 18-Feb-2021

Zelt psi

Drawn By:

METRES
0 1000 2000 3000 4000 5000

NAD83 UTM 11, BASEMAP: GOOGLE EARTH
FILE: P:/2021/2100300-SPRINGBANKDAM/CALCS/AERMOD/Y2013/PM/PD098_TSP_TALLVEG.SRF

Re-Examination of Post Flood
Dry Reservoir Sediment Particulate Emissions
SPRINGBANK OFF-STREAM
RESERVOIR PROJECT

FIGURE A9.4:
200yr (2013) flood
98th% 24h Average
Predicted TSP Concentrations
Including Flooded Area With Silted Vegetation Areas