TECHNICAL MEMORANDUM
LOCKHEED MARTIN CORPORATION

December 11, 2009

TO: Mr. Gene Matsushita

FROM: Mr. Robert Johns

RE: Beaumont Site 1 Numerical Transport Model Development (EESHRLP02179_R605) Plume/COC Conceptual Model Technical Memorandum

EXECUTIVE SUMMARY

This technical memorandum (TM) summarizes Tetra Tech's efforts to develop and document a groundwater plume/contaminant of concern (COC) conceptual model for Lockheed Martin Corporation Beaumont Site 1, Beaumont, California. This TM is the first deliverable for this task order and was undertaken to construct a numerical groundwater transport model for the LMC Beaumont Site 1 Area. This TM utilizes some of the contaminant mass and mass flux information presented in an earlier site TM (Tetra Tech, 2009c).

Key elements of the groundwater plume/COC conceptual model include all aspects of the flow conceptual model given in the recent site groundwater flow model report, as well as the following transport components of the conceptual model:

- Contaminants of Concern – The COCs are perchlorate, 1,4-dioxane, 1,1-DCE, and TCE. There is generally one distinct plume at Site 1 that covers 278 acres. The estimated dissolved mass in groundwater of all COCs in the groundwater plume is 3,925 to 5,943 pounds, with perchlorate accounting for 3,400 to 5,100 pounds; 1,1-DCE accounting for 310 to 500 pounds; TCE accounting for 250 to 370 pounds; and 1,4-dioxane accounting for 100 to 150 pounds. In addition to the mass in groundwater, there is another 1,500 pounds of perchlorate in soils, but no 1,4-dioxane, 1,1-DCE, and TCE are present in soils. Statistical analysis of COC time trends confirms the observation that the overall extent and magnitude of the plume is relatively unchanged over the nearly 20 year monitoring period, though there is a small reduction in plume mass near the RMPA groundwater extraction and treatment system.
- COC Transport – The primary pathway for contaminant migration in groundwater appears to be the coarse-grained, high permeability alluvium/weathered Mount Eden that is primarily located at depth and in the center of valleys. The COCs are generally restricted to the alluvium and weathered Mt. Eden. Groundwater velocity is typically 600 feet per year within the main plume area, such that transport times are approximately 12 years across the 7,200 foot long plume. The maximum COC groundwater underflow rates across the entire plume den.7d06 Tw5t long 0.01,w -22.35 -1.147 T(

This technical memorandum summarizes Tetra Tech's efforts to develop and document a groundwater plume/COC site conceptual model for the LMC Beaumont Site 1 Area. The conceptual model was developed based upon modeling guidance given in ASTM reports (ASTM D 5447-93; ASTM D 5609-94; ASTM D 5490-93; ASTM D 6170-97e, ASTM D 5891) and groundwater modeling guides (Anderson and Woessner, 1992). Per the project workplan, this Conceptual Model TM is submitted for LMC approval prior to construction of the numerical transport model.

Background

The groundwater conceptual model was recently updated in the recent groundwater numerical flow model task (Tetra Tech, 2009b). Key flow-related elements of the conceptual model include the following:

- Groundwater occurs in four primary units: shallow low permeability Quaternary alluvium, deep high permeability Quaternary alluvium/weathered Mount Eden, the competent Mount Eden Formation, and the granitic basement (Figures 1 and 2). The basement rocks provide a base for the shallow water bearing groundwater in the alluvium and weathered Mount Eden, since groundwater in the basement rocks is confined and only found in weathered or fracture zones;
- A small unconfined alluvial basin is found in Bedsprings Creek Valley near the confluence of Potrero and Bedsprings Creeks, with a 100-200 foot thick sequence of saturated recent alluvium located between the Potrero and Bedsprings Faults. All alluvial groundwater eventually discharges to Potrero Creek as the alluvium pinches out against the Mount Eden, although this pinchout occurs downgradient of the extent of the plume as de[Ay2 2d af)]TJ0.0TJ/p2he plh]TJ/C2_0 1 Tf0 Tc 0 Tw

COCs generally found between the main plume and the smaller plume bodies. However, additional sources are also present downgradient of the main COC plume, such as a significant soil source of perchlorate present at the F-33 site which impacts MW-70, and this also impacts the plume shape. The highest concentrations of co

- Contaminant Velocity –The groundwater contaminant velocity is equal to the groundwater velocity divided by the contaminant retardation factor. The retardation factor is assumed to be equal to one for all COCs. While this is a good assumption for perchlorate and 1,4-dioxane, it may be too low for the chlorinated organics (TCE and 1,1-DCE), which can adsorb onto organic carbon in the aquifer solids. This is likely to be most important in the riparian areas where aquifer organic carbon content may not be negligible (Tetra Tech, 2009c). However, since most of the high concentration areas of the Site 1 plume are in the BPA and RMPA above the riparian areas, the assumption of a retardation factor equal to one may not have that large of an influence on the mass of the plume. However, a TCE and 1,1-DCE retardation factor greater than one in the riparian area could have an impact on fate as TCE and 1,1-DCE migrate through the riparian areas into Potrero Creek. Estimates of the aquifer organic carbon content are not currently available, and this is identified as a data gap with recommended data collection for the next wells drilled at the site. For the purposes of this study, it is assumed the retardation factor is equal to 1 for the VOCs due to the low organic carbon content expected for deep groundwater systems in arid environments.
- Contaminant Time Trends – As given in Table 1, time trends in contaminant data for the entire

in soils only amounts to approximately 7 pounds (Table 4), and the soil water phase concentrations in soils only amounts to approximately 33 µg/L. Given the very high groundwater TCE concentrations (as high as approximately 5,000 µg/L) and mass (250-350 pounds), it appears unlikely there is enough TCE in the soils in this area to provide a significant continuing source to the aquifer. Thus, TCE in groundwater is likely maintained at the current high levels due almost solely to the TCE releases from the groundwater sources discussed below. A 1,4-dioxane soil source area is also defined in the same area as the TCE soils source. However, given the very low 1,4-dioxane soil concentrations, the 1,4-dioxane mass and concentration in soils is very small relative to the mass and concentration in groundwater. The only significant soil source areas identified are for perchlorate (Table 4), with perchlorate concentrations over 10,000 µg/kg and a total perchlorate mass of approximately 1,500 pounds. These perchlorate soil sources are located primarily in the BPA (750 pounds), the F-33 area (220 pounds), and the B-11 area (280 pounds). Given that the plume contains approximately 3,000 to 5,000 pounds of perchlorate at

- Dispersion – Dispersion is likely important for all COC given the spatial and temporal variations in flow velocity. Dispersion is estimated through the longitudinal, lateral, and vertical dispersivity values. These factors are dependent on the physical length of the plume. Typically the longitudinal dispersivity is estimated as function of the plume length using methods summarized in USEPA (1998), the lateral dispersivity is estimated as 10 to 33 percent of the longitudinal dispersivity, and the vertical dispersivity is estimated as 1 to 5 percent of the longitudinal dispersivity (US EPA, 1998). Given the 7,200 foot long plume at Beaumont Site 1, the longitudinal dispersivity would be estimated using methods summarized in USEPA (1998).as 50 feet, the lateral dispersivity is estimated as 5 to 17 feet, and the vertical dispersivity is estimated as 0.5 to 2.5 feet. These parameters are also typically adjusted during model calibration since direct measurement typically is not possible, and an upper end parameter range is set at for longitudinal dispersivity at 720 feet using the using methods summarized in USEPA (1998). Note that at this site, large dispersivity values may be needed to explain the high longitudinal concentration gradients observed downgradient of the BPA.
- Sorption – 1,4-dioxane and perchlorate are not subject to physical adsorption, though these contaminants may be retained by hydraulic constraints due to the low permeability of some areas of the aquifer. Sorption also is not likely to be very important for the VOCs since organic carbon fraction and hence sorption is likely small (see “Contaminant Velocity” discussion above). However, it is possible sorption may play a role in VOC transport in the riparian zone, so a retardation factor slightly greater than one may be considered for VOCs in the riparian zone as part of the model calibration and sensitivity analyses. Samples were collected recently from this riparian area during replacement of one of the wells, so data should be available soon for TOC.
- Extraction/Injection – Groundwater extraction and treatment removed VOCs from the aquifer during 1994 through 2002 at the rates shown in Table 3. Perchlorate and 1,4-dioxane were not removed by treatment, although they were transported from the EW-1 and EW-2 extraction locations to the IW-01 through IW-05 injection locations. For transport model purposes, the mass of perchlorate and 1,4-dioxane injected will be set to match the mass extracted for historical operations. For future simulations, the mass of all COCs removed will be calculated within the model based upon COC concentrations and the extraction rate, and the mass injected will be set to zero since it is assumed treatment will be modified to remove perchlorate and 1,4-dioxane.
- Conceptual Model Transport Properties – Based upon the discussion above, Table 5 presents a summary of key transport model parameters.

This plume/COC conceptual model is proposed as the basis for constructing a numerical transport model. Although there are uncertainties in some aspects of the conceptual model, this is typical for hydrogeologic studies, and there do not appear to be any data gaps that would preclude proceeding with a numerical transport model or design of remediation systems. One data gap that has been defined is the aquifer fraction organic in the riparian zone, however, since the bounds for this parameter are reasonably established, parameter uncertainty can be handled within this study as part of the model calibration and sensitivity analyses.

COC Mass Flux Budget

A preliminary groundwater COC mass flux budget is defined as part of the basis for constructing the numerical transport model. The underflow mass flux numbers are quite uncertain at this point in the study and subject to change during calibration. Both soil and groundwater sources are considered as part of the conceptual model and COC mass flux budget, with a separate source life for the groundwater and soil sources and potentially each COC. Source life for soils sources is estimated based upon the current release rates and mass, though this method is really only important for perchlorate since TCE has only a very small soils mass and 1,4-dioxane and 1,1-DCE are not present in soils. Source life for groundwater sources is estimated based upon Case Studies at similar sites and the experience to date at this site, which strongly suggests that if left untreated these groundwater sources would likely continue for decades. Since the model cases anticipated in this project will likely be limited to periods on the order of 20 years, these groundwater source releases will be continued indefinitely into the future for future simulations with no groundwater source remediation and projected into the past for historical simulations. For model runs considering remediation of the groundwater sources, these groundwater source releases will be continued into the future for a time period on the order of 2 to 10 years depending upon the recommendations of the remedial action team.

Key elements of the groundwater COC mass flux budget are as follows:

- Alluvial Aquifer Recharge and Sources – Recharge to the alluvium is primarily from direct precipitation, creek recharge, and injection. COC mass flux for these items are as follows:
  - Direct Precipitation – COC mass flux is estimated for precipitation leaching COCs from the soil source areas into groundwater using the average diffuse recharge rate of 2.4 inches per year from the calibrated flow model, and the COC soil areas and concentrations identified in Figures 7 through 9 (Table 4). The main soil source is for perchlorate, with the total perchlorate flux from soils being approximately 100 pounds per year. Perchlorate flux from the BPA soils at C-22 is 73 of the 100 pounds per year, with 20 of the 100 pounds per year from the RMPA soils at B-9/B-11, and 7 of the 100 pounds per year from the other areas (Figure 7). There is also one small TCE soils source in the BPA, with a mass flux of approximately one-third of a pound per year. The duration of these soil sources generally varies between 10 to 25 years depending on the total mass present (Table 4), and the timing of these releases may vary seasonally with the seasonal variation in recharge and groundwater levels. There is no significant COC mass flux from soils for 1,1-DCE and 1,4-dioxane.
  - Recharge from Creeks – For all COCs, there is no significant COC mass flux due to creek recharge, as soils in the creek recharge areas do not appear to be contaminated.
  - Underflow – There is no significant underflow into the alluvium, so there is also no significant COC inflow from the alluvium boundaries. Soils are also assumed to be free from contamination at the upgradient limits of the alluvium. Within the alluvium, there are possible internal groundwater sources treated as underflow (see discussion below). The maximum COC underflow rates across the entire plume width are approximately 30-40 pounds per year for 1,1-DCE; 20-30 pounds per year for TCE; 200-400 pounds per year for perchlorate; and 8-12 pounds per year for 1,4-dioxane (Figure 11). These flux values decrease slightly with distance below the BPA until reaching the riparian area, where they decrease markedly. The decline in mass flux rate through the riparian area is greatest for perchlorate and least for 1,4-dioxane, with 1,4-dioxane having one of the higher COC mass flux rates in portions of the riparian area even though 1,4-dioxane has the lowest mass flux rate in the BPA. Figure 11 also shows an apparent rebound in perchlorate mass flux below the riparian area that may be attributed to the limited precision of the mass flux estimates, or potentially the back end of a pulse of higher concentration releases since site monitoring data has shown possible pulses of COCs moving through the Potrero Creek area. The rebound area is further complicated by

- Sinks – COCs also appear to be lost from the plume by degradation in the riparian area. The loss is most obvious for perchlorate, although COC trends suggest some degree of attenuation may also be occurring for 1,1-DCE and TCE. Using the COC decay rates given above, the COC mass flux rate into the riparian areas, and the 4 year residence time in the riparian area, the mass loss rate due to degradation in the riparian area is estimated as follows: 3 pounds per year for 1,1-DCE; 2 pounds per year for TCE; 40 pounds per year for perchlorate; and 0 pounds per year for 1,4-dioxane. There is considerable uncertainty in these degradation estimates, however, the transport modeling work will also provide an assessment on the likely magnitude of groundwater degradation rates.
- Net Budget – The net mass flux budget is summarized in flow diagrams in Figure 12. Generally, the mass inflow rates are approximately equal to the mass outflow rates, given the limited precision of these estimates. The flux diagram for perchlorate may imply accumulation of mass, but this is due to uncertainty in these estimates, and values will be refinint per y

to serve as a guide for the m

,..89 0 TJ0Some elements of the COC mass flux budget will mst likely be revisi

,..89 0 TJ process.

TABLES

Table 1
Statistical Analysis of Groundwater Monitoring Data
LMC Beaumont Site 1
Data from August 1986 to June 2009

			Mean						Mean						Mean						Mean			
Well	**Num Samples**	**Num Detects**	**(g/L)**	**Trend**	**(%/yr)**	**(g/L/yr)**	**Num Samples**	**Num Detects**	**(g/L)**	**Trend**	**(%/yr)**	**(g/L/yr)**	**Num Samples**	**Num Detects**	**(g/L)**	**Trend**	**(%/yr)**	**(g/L/yr)**	**Num Samples**	**Num Detects**	**(g/L)**	**Trend**	**(%/yr)**	**(g/L/yr)**
EW-01	11	11	140.0	D	-7.5	-10.4	12	12	290.0	PD	-16.1	-46.6												
EW-02	10	10	150.0	I	3.1	4.6	12	12	260.0	PD	-9.2	-23.9												
EW-08	5	5	10.0	S			5	5	17.0	S														
EW-09	5	5	140.0	NT			5	5	420.0	S														
EW-10	4	4	220.0	I	17.5	38.57	5	5	810.0	S														
EW-11	8	8	530.0	NT			15	15	1,000.0	NT														
EW-12	11	11	1,300.0	(%/yr)																				

Table 1

Table 1
Statistical Analysis of Groundwater Monitoring Data
LMC Beaumont Site 1
Data from August 1986 to June 2009

	TCE		TCE Mean		TCE Magnitude of Trend		DCE		1,1-DCE Mean		1,1-DCE Magnitude of Trend	
Well	**Num Samples**	**Num Detects**	**(g/L)**	**Trend**	**(%/yr)**	**(g/L/yr)**	**Num Samples**	**Num Detects**	**(g/L)**	**Trend**	**(%/yr)**	**(g/L/yr)**
MW-85B	2	2	65.0	N/A			2	0	0.1	N/A		
MW-86A	2	0	0.1	N/A			2	0	0.1	N/A		
MW-86B	2	2	84.0	N/A			2	0	0.1	N/A		
MW-87A	2	2	0.5	N/A			2	1	0.3	N/A		
MW-87B	2	2	50.0	N/A			2	2	13.0	N/A		
MW-88	2	0	0.1	N/A			2	0	0.2	N/A		
MW-89	2	2	5.6	N/A			2	2	3.9	N/A		
MW-90	2	2	1.9	N/A			2	2	1.7	N/A		
MW-91	2	1	0.7	N/A			2	1	0.6	N/A		
MW-92	2	2	17.0	N/A			2	0	0.1	N/A		
MW-93	2	2	1.8	N/A			2	2	0.5	N/A		
MW-94	2	2	1.7	N/A			2	2	0.3	N/A		
MW-95	2	2	14.0	N/A			2	0	0.1	N/A		
MW-96	2	0	0.1	N/A			2	0	0.2	N/A		
MW-97	2	0	0.1	N/A			2	0	0.2	N/A		
MW-98A	2	0	0.1	N/A			2	0	0.1	N/A		
MW-98B	2	2	14.0	N/A			2	2	8.0	N/A		
MW-99	2	2	2.2	N/A			2	2	3.9	N/A		
OW-01	9	1	0.4	NT			8	1	1.9	NT		
OW-02	17	17	78.0	D	-5.1	-4.0	17	17	77.0	D	-5.3	-4.0
OW-03	13	13	200.0	D	-8.2	-16.4	16	16	160.0	D	-9.6	-15.4
OW-08	9	0	0.2	S			9	0	0.2	S		
P-02	9	1	0.5	NT			9	1	1.7	NT		
P-03	7	1	0.5	NT			7	2	2.2	PD	-10.8	-0.2
P-04	4	1	0.7	NT			4	1	3.4	NT		
P-05	9	3	6.6	PD	-4.7	-0.3	9	3	5.7	PD	-6.0	-0.3
Notes:	1,291	948	6.64				1,478	1,135	9.20			
	Total	Total	GeoMean				Total	Total	GeoMean			

	Perc		Perchlorate[1] Mean		Perchlorate[1] Magnitude of Trend		Diox		1,4-Dioxane[2] Mean		1,4-Dioxane[2] Magnitude of Trend	
Well	**Num Samples**	**Num Detects**	**(g/L)**	**Trend**	**(%/yr)**	**(g/L/yr)**	**Num Samples**	**Num Detects**	**(g/L)**	**Trend**	**(%/yr)**	**(g/L/yr)**
MW-85B	0	0	0.5	N/A			2	1	0.6	N/A		
MW-86A	0	0	0.2	N/A			2	1	1.3	N/A		
MW-86B	0	0	0.2	N/A			2	1	3.4	N/A		
MW-87A	0	0	0.2	N/A			2	2	5.1	N/A		
MW-87B	2	0	39.0	N/A			2	2	63.0	N/A		
MW-88	2	0	410.0	N/A			2	0	0.3	N/A		
MW-89	2	0	2,000.0	N/A			2	2	5.7	N/A		
MW-90	2	0	200.0	N/A			2	0	0.3	N/A		
MW-91	2	0	1,800.0	N/A			2	2	1.3	N/A		
MW-92	2	0	25.0	N/A			2	0	0.3	N/A		
MW-93	1	0	1.1	N/A			2	2	12.0	N/A		
MW-94	1	0	1.2	N/A			2	2	5.6	N/A		
MW-95	0	0	0.2	N/A			2	0	0.3	N/A		
MW-96	0	0	0.2	N/A			2	0	0.3	N/A		
MW-97	0	0	0.2	N/A			2	0	0.3	N/A		
MW-98A	0	0	0.2	N/A			2	0	0.3	N/A		
MW-98B	2	0	1,100.0	N/A			2	2	6.9	N/A		
MW-99	2	0	530.0	N/A			2	1	1.3	N/A		
OW-01	0	0	0.4	S			6	0	0.4	S		
OW-02	11	1	670.0	D	-4.2	-28.4	10	10	15.0	D	-4.5	-0.7
OW-03	2	0	1,900.0	N/A			1	1	45.0	N/A		
OW-08	0	0	17.0	S			5	0	0.4	S		
P-02	0	0	0.3	S			7	0	0.3	S		
P-03	1	2	0.8	NT			6	2	0.9	S		
P-04	0	0	0.2	N/A			3	0	0.2	N/A		
P-05	6	1	4.9	S			7	1	0.4	S		
Notes:	423	64	24.26				669	424	3.10			
	Total	Total	GeoMean				Total	Total	GeoMean			

Trend Categories	**TCE (# wells)**	**% Total**	**1,1-DCE (# wells)**	**% Total**	**Perchlorate (# wells)**	**% Total**	**1,4-Dioxane (# wells)**	**% Total**
"N/A"-Insufficient Data	36		36		51		50	
Blank-No data	0		0		23		25	
"NT" - No Trend	40	31	38	29	26	28	31	34
"S" - Stable	46	35	44	34	42	46	51	56
"I" - Increasing	8	6	4	3	7	8	3	3
"PI" -Probably Increasing	2	2	1	1	1	1	0	0
"D" - Decreasing	25	19	34	26	13	14	3	3
"PD" -Probably Decreasing	9	7	9	7	3	3	3	3

Definitii8c0 456 -4563 Td(Definitii8c0 456 -4563 Td(Definitii8c0 5iW4S Stab)T388447 0aby/TT1 1 N 368 0 Td(9)T8263 0 Td(385initii8c0 5iW4S Sl)T388447 0aby/7E6-3MTota47 0 aly/TT1 1 N 368 0 Td(9)T82630110 456 -4563 Td(Definitii8c0 456 T1 1ii85431716 TPage 3 of 24)T0 456 -456 0 1ii43 Tm63331716 T (4)t T

Table 1
Statistical Analysis of Groundwater Monitoring Data
LMC Beaumont Site 1
Data from August 1986 to June 2009

Num Samples	Num Detects	Mean (g/L)	Trend	(%/yr)	(g/L/yr)	Num Samples	Num Detects	Mean (g/L)	Trend	(%/yr)	(g/L/yr)	Num Samples	Num Detects	Mean (g/L)	Trend	(%/yr)	(g/L/yr)	Num Samples	Num Detects	Mean (g/L)	Trend	(%/yr)	(g/L/yr)	µ
11	11	19	D	-16.1	-3.1	9	8	1.9	S			11	11	8.6	D	-23.4	-2.0	4	4	0.75	S			
12	12	37.0	D	-17.5	-6.5	10	10	3.3	S			11	11											

Table 1
Statistical Analysis of Groundwater Monitoring Data
LMC Beaumont Site 1
Data from August 1986 to June 2009

1,1,1,-TCA		Mean		1,1,1-TCA Magnitude of Trend		1,1-DCA		Mean		1,1-DCA Magnitude of Trend		1,2-DCA		Mean		1,2-DCA Magnitude of Trend		cis--DCE		Mean		cis--DCE Magnitude of Trend	
Num Samples	Num Detects	(g/L)	Trend	(%/yr)	(g/L/yr)	Num Samples	Num Detects	(g/L)	Trend	(%/yr)	(g/L/yr)	Num Samples	Num Detects	(g/L)	Trend	(%/yr)	(g/L/yr)	Num Samples	Num Detects	(g/L)	Trend	(%/yr)	(g/L/yr)
6	1	0.4	NT			5	0	0.3	S			6	1	0.4	NT			4	0	0.2	S		
24	23	5.1	D	-6.9	-0.4	23	16	1.2	D	-3.8	0.0	24	15	4.6	D	-7.7	-0.4	17	9	0.4	D	-6.9	0.0
17	17	16.0	D	-20.5	-3.3	15	15	0.8	D	-6.1	0.0	17	17	2.8	D	-9.9	-0.3	10	9	0.6	D	-8.8	-0.1
17	17	13.0	D	-12.3	-1.6	14	14	2.0	NT			17	16	9.2	D	-19.0	-1.7	9	8	0.6	D	-8.6	0.0
18	18	27.0	D	-14.6	-3.9	14	14	1.7	S			18	17	16.0	D	-20.5	-3.3	10	9	0.6	D	-8.8	-0.1
8	4	6.5	PD	-11.7	-0.8	6	0	0.3	S			8	2	5.4	PD	-12.6	-0.7	6	0	0.2	S		
8	4	92.0	D	-16.1	-14.8	6	3	0.7	NT			8	7	5.4	D	-9.5	-0.5	6	0	0.2	S		
20	18	12.0	D	-8.6	-1.0	18	18	2.9	S			20	20	3.3	NT			13	11	1.2	S		
21	16	2.2	D	-8.3	-0.2	18	13	0.5	D	-3.8	0.0	21	16	4.2	D	-9.1	-0.4	13	8	0.5	D	-6.4	0.0
9	5	5.4	D	-10.5	-0.6	7	7	1.4	S			10	8	6.8	D	-8.3	-0.6	7	2	0.4	PD	-5.7	0.0
24	22	9.3	D	-9.5	-0.9	21	20	2.0	D	-2.0	0.0	24	23	7.2	D	-4.2	-0.3	16	9	0.6	D	-5.7	0.0
8	6	9.9	D	-14.6	-1.4	6	6	1.8	D	-2.5	0.0	9	9	11	D	-8.5	-0.9	6	3	0.55	PD	-9.8	-0.1
18	18	12.0	D	-11.0	-1.3	16	16	2.1	NT			18	18	11.0	PD	-8.9	-1.0	11	8	0.9	D	-8.2	-0.1
7	6	8.5	D	-10.7	-0.9	5	5	1.6	S			7	7	3.3	NT			5	2	0.5	NT		
6	6	13.0	D	-10.5	-1.4	4	4	1.6	S			6	6	8.0	D	-6.9	-0.5	4	2	0.6	S		
7	6	21.0	D	-13.4	-2.8	5	5	1.6	D	-2.8	0.0	7	6	24.0	D	-12.9	-3.1	5	2	0.5	NT		
9	7	10.0	D	-14.6	-1.5	6	4	0.7	S			9	6	10.0	D	-13.7	-1.4	6	3	0.5	D	-9.8	0.0
6	5	9.0	D	-14.5	-1.3	5	2	0.8	PD	-8.0	-0.1	6	3	1.2	D	-10.8	-0.1	5	2	0.5	NT		
8	7	19.0	D	-14.6	-2.8	5	2	0.6	NT			8	5	26.0	D	-17.5	-4.6	5	2	0.5	NT		
20	19	15.0	D	-13.9	-2.1	17	17	2.2	S			20	19	18.0	D	-8.6	-1.6	12	7	0.5	D	-11.0	-0.1
6	4	1.8	D	-6.6	-0.1	5	3	0.9	S			7	5	2.5	D	-7.2	-0.2	4	2	0.6	S		
18	15	17.0	D	-14.2	-2.4	15	15	13.0	D	-1.9	-0.2	18	18	37.0	D	-3.7	-1.4	10	9	1.7	S		
8	5	5.3	PD	-11.1	-0.6	5	5	6.2	I	4.8	0.3	8	8	12.0	I	3.7	0.4	5	3	0.6	S		
16	11	12	D	-11.4	-1.4	13	13	16	NT			15	15	42	NT			13	11	1.8	NT		
14	12	1.6	D	-3.5	-0.1	12	12	3.6	I	4.7	0.2	15	15	5.5	I	3.4	0.2	12	11	1.4	I	2.2	0.0
10	4	0.7	D	-5.7	0.0	8	5	0.5	S			10	5	0.8	D	-5.1	0.0	8	2	0.4	PD	-4.4	0.0
10	8	20.0	D	-10.7	-2.1	6	6	3.2	NT			10	10	28.0	PD	-2.6	-0.7	5	4	1.1	S		
13	11	440.0	D	-11.4	-50.1	10	10	180.0	D	-2.8	-5.0	13	12	430.0	D	-7.2	-30.8	8	6	39.0	D	-5.3	-2.1
7	3	6.6	D	-10.1	-0.7	5	5	1.6	NT			7	7	4.8	NT			5	2	0.4	NT		
3	3	3.3	N/A			1	1	1.0	N/A			3	3	2.6	N/A			1	1	1.0	N/A		
24	22	35.0	D	-13.6	-4.8	21	20	2.0	D	-2.6	-0.1	24	19	41.0	D	-11.7	-4.8	16	8	0.4	D	-7.2	0.0
5	5	90.0	D	-36.5	-32.9	2	2	3.9	N/A			5	5	60.0	NT			2	2	1.0	N/A		
9	9	4.4	PD	-12.3	-0.5	8	8	1.2	NT			9	9	2.4	NT			5	4	0.4	S		
1	1	48.0	N/A									1	1	49.0	N/A								
3	3	35.0	N/A			2	2	4.0	N/A			3	3	4.7	N/A			2	2	1.0	N/A		
22	16	5.2	D	-14.6	-0.8	21	21	4.3	S			22	21	1.6	PD	-2.9	0.0	15	8	0.8	D	-8.2	-0.1
11	0	0.3	S			11	0	0.3	S			11	0	0.2	S			10	0	0.2	S		
7	0	0.2	S			7	0	0.2	S			7	0	0.2	S			7	0	0.3	S		
7	0	0.2	S			6	2	0.3	S			7	0	0.2	S			7	0	0.3	S		
9	0	0.2	S			8	0	0.2	S			9	0	0.2	S			9	0	0.2	S		
4	0	0.2	S			4	0	0.2	S			4	0	0.2	S			4	0	0.3	S		
5	0	0.2	S			5	0	0.2	S			5	0	0.2	S			5	0	0.3	S		
4	0	0.2	S			4	0	0.2	S			4	0	0.2	S			4	0	0.3	S		
4	0	0.2	S			4	0	0.2	S			4	0	0.2	S			4	0	0.3	S		
4	0	0.3	S			4	0	0.3	S			4	0	0.3	S			4	0	0.4	S		
4	0	0.3	S			4	0	0.3	S			4	0	0.3	S			4	0	0.4	S		
4	0	0.3	S			4	0	0.3	S			4	0	0.3	S			4	0	0.4	S		
4	0	0.3	S			4	0	0.3	S			4	0	0.3	S			4	0	0.4	S		
4	0	0.3	S			4	0	0.3	S			4	0	0.3	S			4	0	0.4	S		
4	0	0.3	S			4	0	0.3	S			4	0	0.3	S			4	0	0.4	S		
5	0	0.3	S			5	0	0.3	S			5	0	0.3	S			5	0	0.4	S		
4	0	0.3	S			4	0	0.3	S			4	0	0.3	S			4	0	0.4	S		
5	0	0.3	S			5	0	0.3	S			5	0	0.3	S			5	0	0.3	S		
6	0	0.3	S			6	0	0.3	S			6	0	0.2	S			6	0	0.3	S		
5	0	0.3	S			5	0	0.3	S			5	0	0.3	S			5	0	0.3	S		
5	0	0.3	S			5	0	0.3	S			5	0	0.3	S			5	0	0.3	S		
6	0	0.3	S			6	0	0.1	S			6	0	0.2	S			6	0	0.3	S		
4	0	0.3	S			4	2	0.5	NT			4	0	0.3	S			4	1	0.5	NT		
5	0	0.3	S			5	0	0.3	S			5	0	0.3	S			5	0	0.3	S		
6	0	0.3	S			6	0	0.3	S			6	0	0.2	S			6	0	0.3	S		
5	0	0.3	S			5	0	0.3	S			5	0	0.3	S			5	0	0.4	S		
5	0	0.3	S			5	0	0.3	S			5	0	0.3	S			5	0	0.3	S		
4	1	0.4	NT			4	2	0.4	NT			4	0	0.3	S			4	0	0.4	S		
5	0	0.3	S			5	3	0.4	S			5	0	0.3	S			4	1	0.4	NT		
5	0	0.3	S			5	0	0.3	S			5	0	0.3	S			5	0	0.3	S		
4	0	0.1	S			4	0	0.1	S			4	0	0.1	S			4	0	0.1	S		
4	0	0.1	S			4	0	0.1	S			4	0	0.1	S			4	0	0.1	S		
2	0	0.2	N/A			2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.2	N/A		
2	0	0.2	N/A			2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.2	N/A		
2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.2	N/A		

Table 1
Statistical Analysis of Groundwater Monitoring Data
LMC Beaumont Site 1
Data from August 1986 to June 2009

1,1,1,-TCA		Mean	1,1,1-TCA Magnitude of Trend			1,1-DCA		Mean	1,1-DCA Magnitude of Trend			1,2-DCA		Mean	1,2-DCA Magnitude of Trend			cis--DCE		Mean	cis--DCE Magnitude of Trend		
Num Samples	Num Detects	(g/L)	Trend	(%/yr)	(g/L/yr)	Num Samples	Num Detects	(g/L)	Trend	(%/yr)	(g/L/yr)	Num Samples	Num Detects	(g/L)	Trend	(%/yr)	(g/L/yr)	Num Samples	Num Detects	(g/L)	Trend	(%/yr)	(g/L/yr)
2	0	0.1	N/A			2	1	0.2	N/A			2	0	0.1	N/A			2	1	0.2	N/A		
2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.2	N/A		
2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.1	N/A			2	2	1.3	N/A		
2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.2	N/A		
2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.2	N/A		
2	0	0.2	N/A			2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.2	N/A		
2	0	0.2	N/A			2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.2	N/A		
2	0	0.2	N/A			2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.2	N/A		
2	0	0.2	N/A			2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.2	N/A		
2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.2	N/A		
2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.1	N/A		
2	0	0.1	N/A			2	1	0.1	N/A			2	0	0.1	N/A			2	0	0.1	N/A		
2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.2	N/A		
2	0	0.2	N/A			2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.2	N/A		
2	0	0.2	N/A			2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.2	N/A		
2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.2	N/A		
2	0	0.1	N/A			2	1	0.2	N/A			2	0	0.1	N/A			2	0	0.2	N/A		
2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.1	N/A			2	0	0.2	N/A		
9	1	0.6	NT			8	0	0.3	S			9	1	0.2	NT			5	0	0.2	S		
16	11	31.0	D	-12.4	-3.8	15	9	2.1	NT			15	4	0.5	NT			11	0	0.3	S		
17	17	49.0	D	-16.1	-7.9	18	16	5.8	D	-10.2	-0.6	17	14	1.9	NT			8	7	3.1	D	-14.0	-0.4
9	0	0.2	S			9	0	0.3	S			9	0	0.1	S			5	0	0.2	S		
9	1	0.6	NT			8	0	0.3	S			9	1	0.3	NT			6	0	0.2	S		
7	1	0.7	NT			6	0	0.3	S			7	1	0.3	NT			5	0	0.2	S		
4	1	0.9	NT			3	0	0.2	N/A			4	1	0.3	NT			3	0	0.1	N/A		
9	3	0.5	PD	-2.8	0.0	8	2	0.5	NT			9	2	0.4	PD	-5.0	0.0	7	1	0.3	NT		
1,466	857					1,291	755	0.72				1,470	850	1.13				1,015	422	0.44			
Total	Total	GeoMean				Total	Total	GeoMean				Total	Total	GeoMean				Total	Total	GeoMean			

1,1,1-TCA (# wells)	% Total	1,1-DCA (# wells)	% Total	1,2-DCA (# wells)	% Total	cis-DCE (# wells)	% Total
37		38		36		37	
0		5		0		7	
27	21	30	24	51	39	27	22
38	29	69	56	42	32	65	53
0	0	5	4	3	2	3	2
0	0	0	0	0	0	0	0
56	43	18	15	26	20	20	16
8	6	1	1	8	6	7	6
129	100	123	100	130	100	122	100

Table 2
2008 Aquifer Plume Volume and Mass Estimates
Beaumont Site 1

Site and COCs	Area above MCL (acres)	Water Volume above MCL (acre-feet)	Mass (pounds) using maximum concentration at any depth	Mass (pounds) using depth averaged concentration	Comment
Site 1					
Perchlorate	227	2,529	5,083	3,364	
1,1-DCE	154	1,742	496	312	
TCE	145	1,550	365	249	
1,4-dioxane	179	2,081	147	102	
All COCs	278	3,018	5,943	3,925	All COCs driven by Perchlorate except in the Riparian Areas where it drops below MCL

Table 3
Site 1 RMPA Groundwater Extraction Volumes and Mass Removals

Quarterly Period	Start Date	End Date	End Cumulative Volume (gallons)	Period Volume (gals)	EW-1 Volume (gals)	EW-1 1,1-DCE Concentration (ug/L)	EW-1 1,1-DCE Mass Removal (Kg)	EW-1 TCE Concentration (ug/L)	EW-1 TCE Mass Removal (Kg)	EW-1 1,1,1 TCA Concentration (ug/L)	EW-1 1,1,1 TCA Mass Removal (Kg)	EW-1 DCAs Concentration (ug/L)	EW-1 DCAs Mass Removal (Kg)	EW-2 Volume (gals)	EW-2 1,1-DCE Concentration (ug/L)	EW-2 1,1-DCE Mass Removal (Kg)	EW-2 TCE Concentration (ug/L)	EW-2 TCE Mass Removal (Kg)	EW-2 1,1,1 TCA Concentration (ug/L)	EW-2 1,1,1 TCA Mass Removal (Kg)	EW-2 DCAs Concentration (ug/L)	EW-2 DCAs Mass Removal (Kg)
1	10/1/92	12/31/92	0	0	0	1,150.0		360														

Table 4
COC Mass Flux Summary

		Comments	
Groundwater Diffuse Recharge Rate	2.42 in/yr	0.20	ft/yr
Soil Water Content	0.10		
Soil Air Content	0.20		
area, acres	10		
thickness, feet	50		
Total Soil TCE Concentration, ug/kg	4	equilibrium with soil gas	

Table 4
COC Mass Flux Summary

area, acres	0.35
Total Soil Concentration, ug/Kg >200	200
area acres	0.05
Total Soil Concentration, ug/Kg >1,000	1000

Table 5
Summary of Tranport Model Parameters
Beaumont Site 1

Parameter	Value	Source
Transport		
Total porosity[1]	0.2	Radian 1992 Hydrogeologic Study; Tetra Tech, 2009c
Effective porosity[2]	0.1	Flow Model Specific Yield Value, Tetra Tech, 2009b
Longitudinal dispersivity	50 feet	US EPA, 1998
Transverse dispersivity	1/10 to 1/3 * α_L	US EPA, 1998
Vertical dispersivity	1/100 to 1/20 * α_L	US EPA, 1998
Dry bulk density[3]	1.5 g/cm3	site data average
Fraction organic carbon	0 to 0.0001	assumption (VOC Retardation Factor ~ 1 to 1.2)
perchlorate degradation rate	2 $year^{-1}$	site data trends
TCE degradation rate	0.04 $year^{-1}$	site data trends
1,1-DCE degradation rate	0.02 $year^{-1}$	site data trends
1,4-dioxane degradation rate	0 $year^{-1}$	conservative transport

Definitions:

α_L - Longitudinal dispersivity.

g/cm^3 - Grams per cubic centimeter.

[1]The total porosity cited is not the true total porosity that would be measured in a lab sample, but a field scale value for model grid blocks and estimating plume mass. This value excludes lower permeability interbeds in the aquifer, and is hence less than the true total porosity. The 20 percent value is also consistent with the value used in earlier site mass estimates.

[2]The effective porosity excludes interbeds and also accounts for fast and slow paths through the remaining beds.

[3]The bulk density value is the true aquifer bulk density that would be measured in a lab sample, and thus may appear inconsitent with the field scale total porosity value given above.

FIGURES

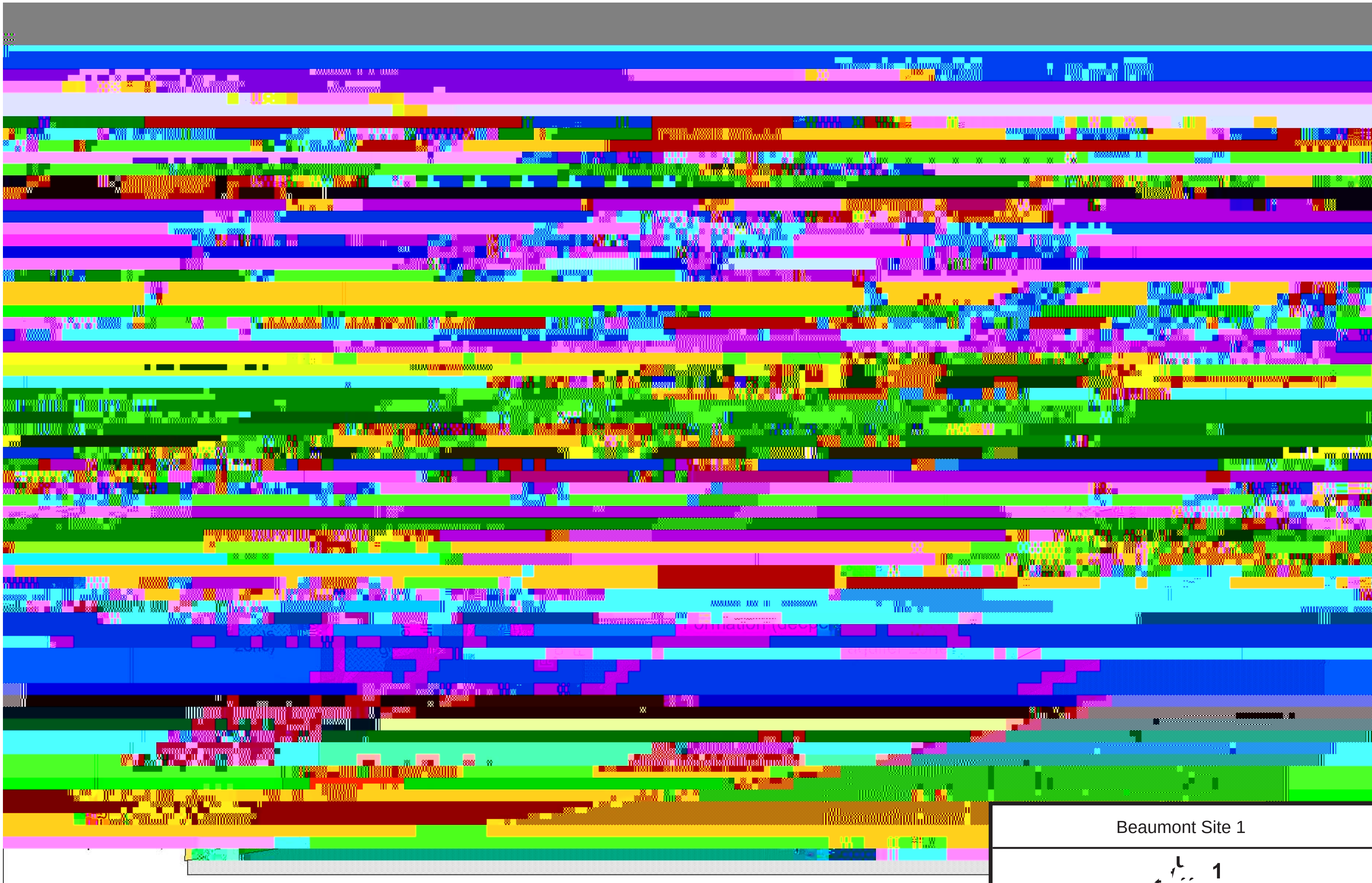

Illustration not to scale.

Beaumont Site 1

TETRA TECH

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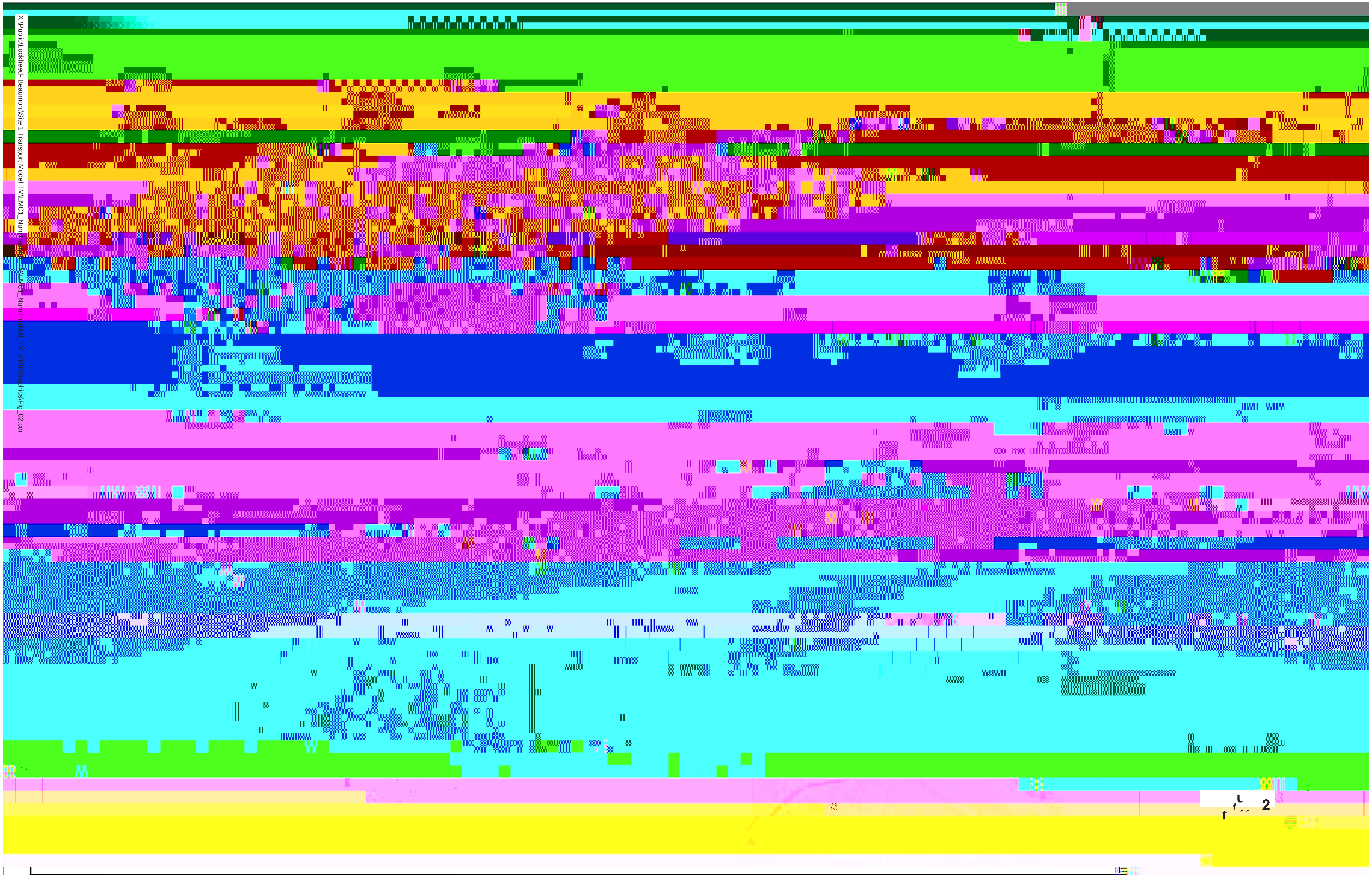

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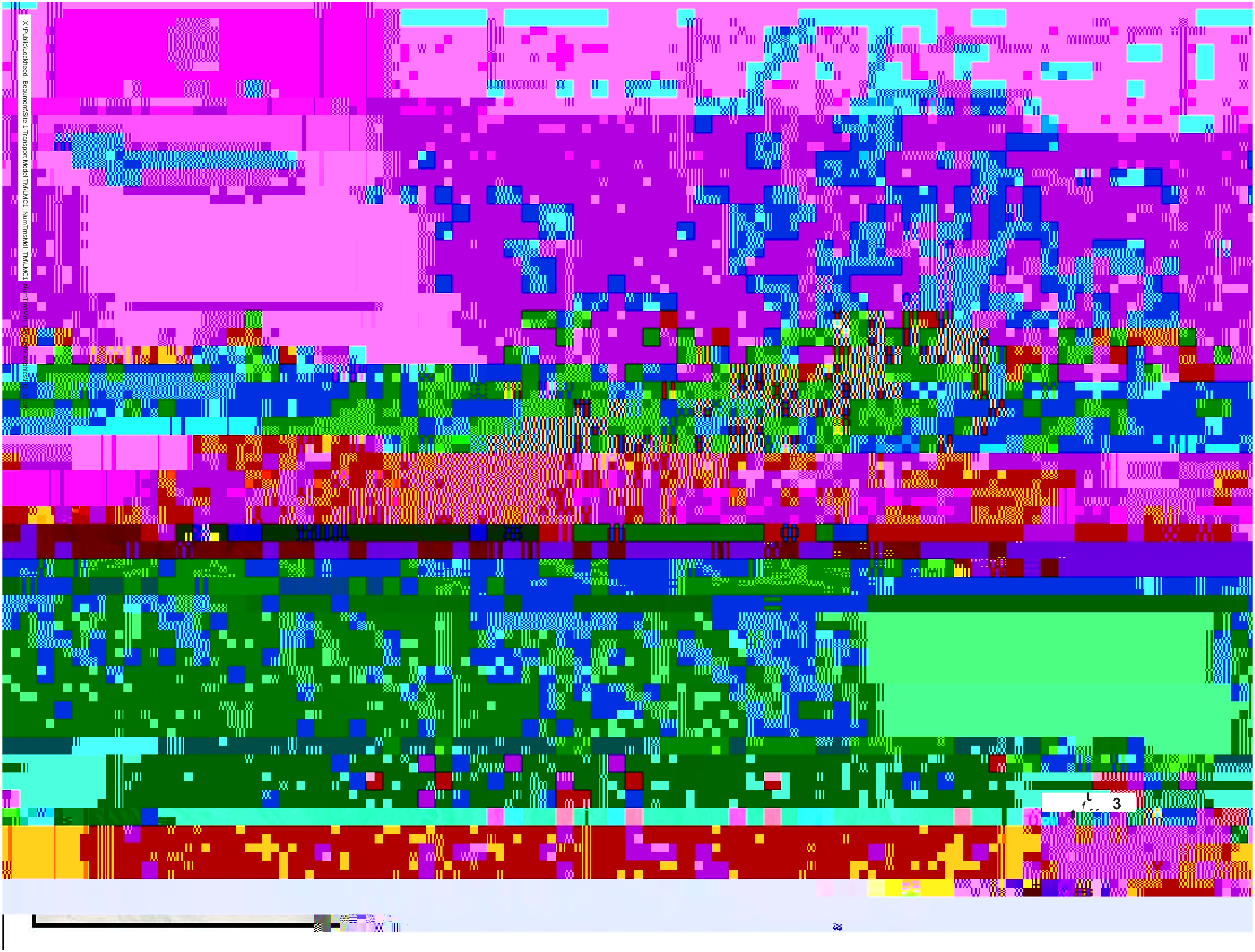
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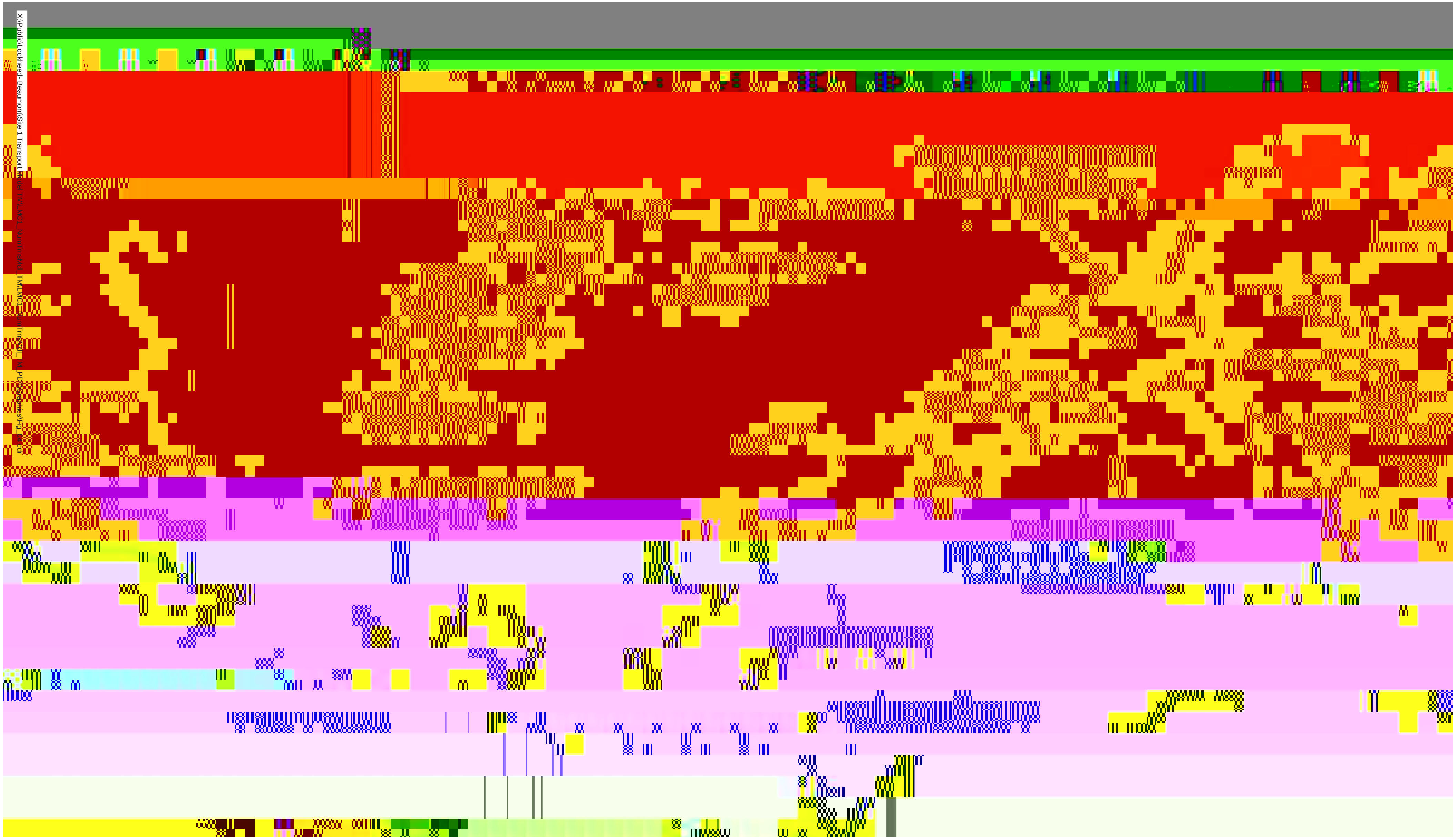
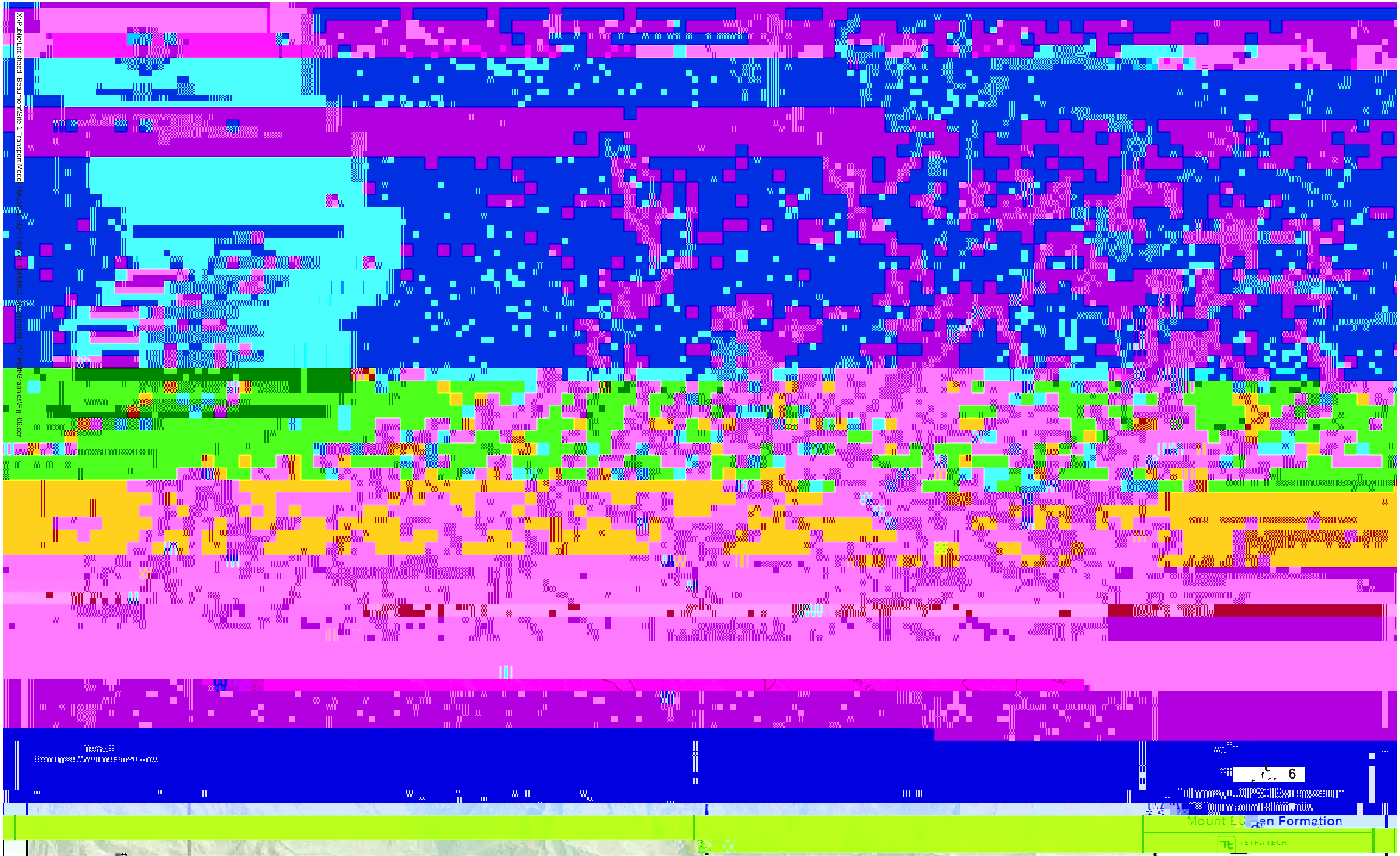


Beaumont Site 1

Figure 4.1
MODFLOW Model Boundary Conditions for Shallow Alluvium Weathered Mt. Eden (Layer 1)


6
Mount L
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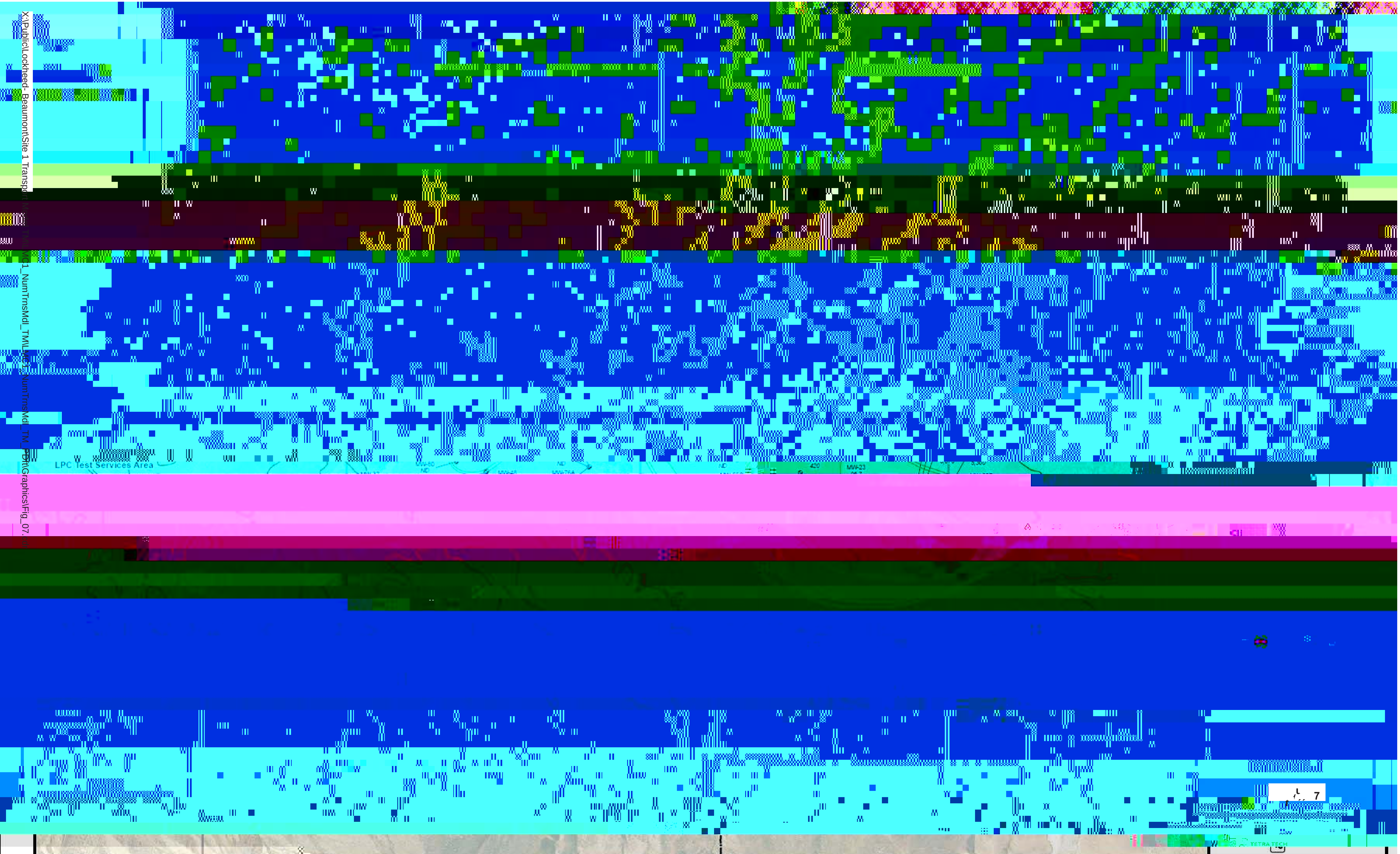
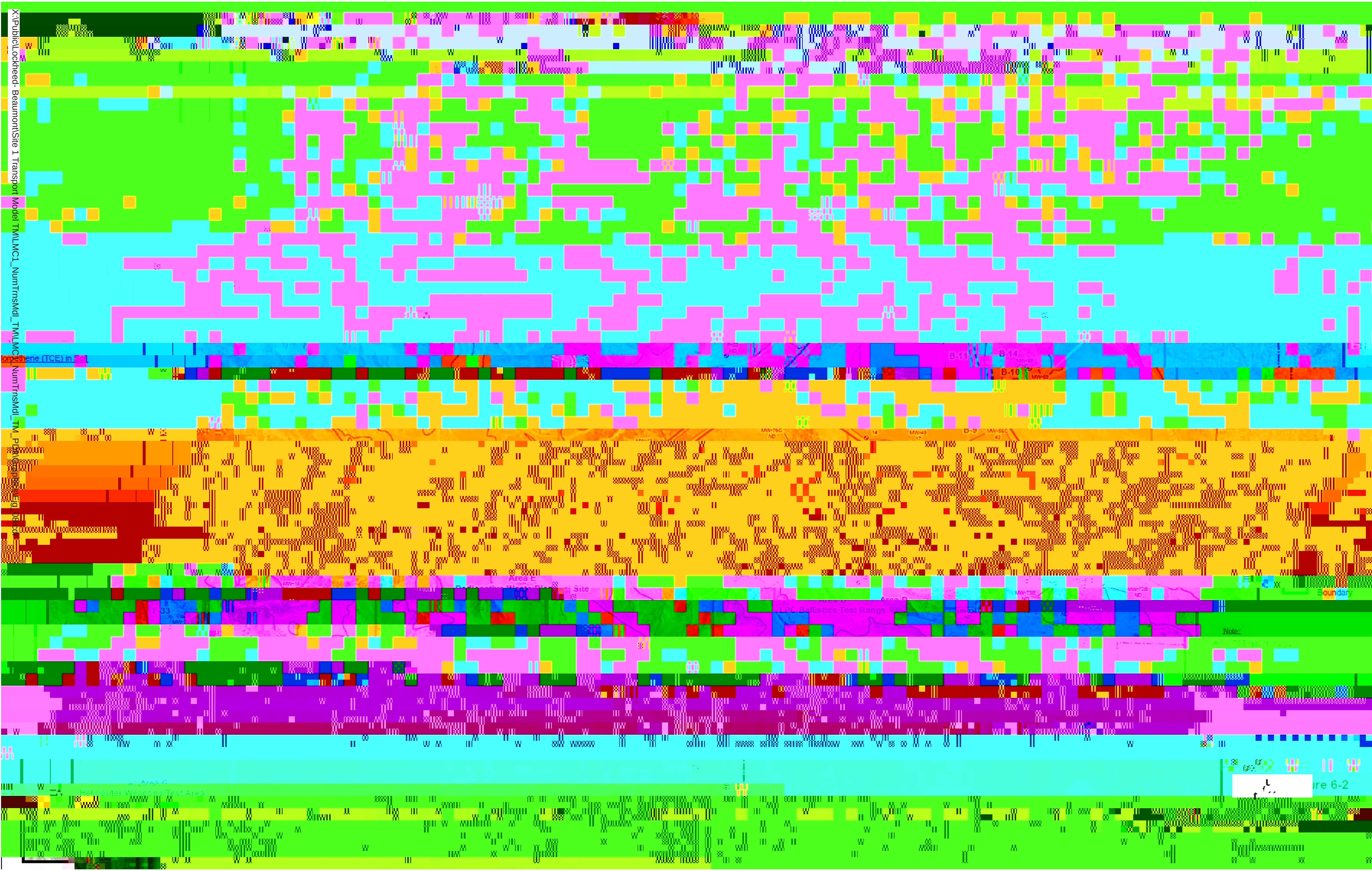
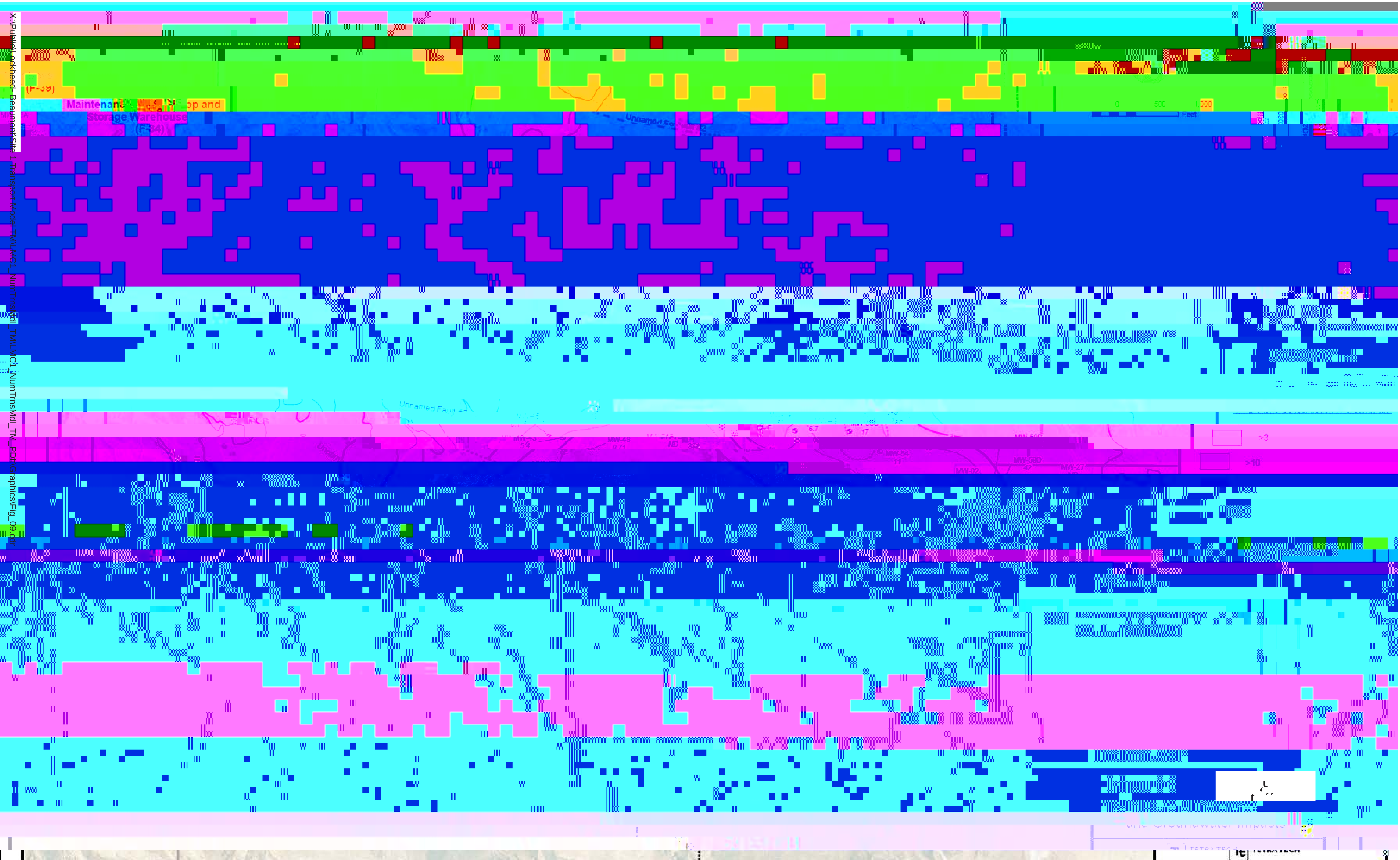

LPC Test Services Area
TETRA TECH



Area E
LPC Ballistics Test Range
Boundary
B-11
B-14
B-10


(F-39)
Storage Warehouse
(F-34)
Feet
TETRA TECH

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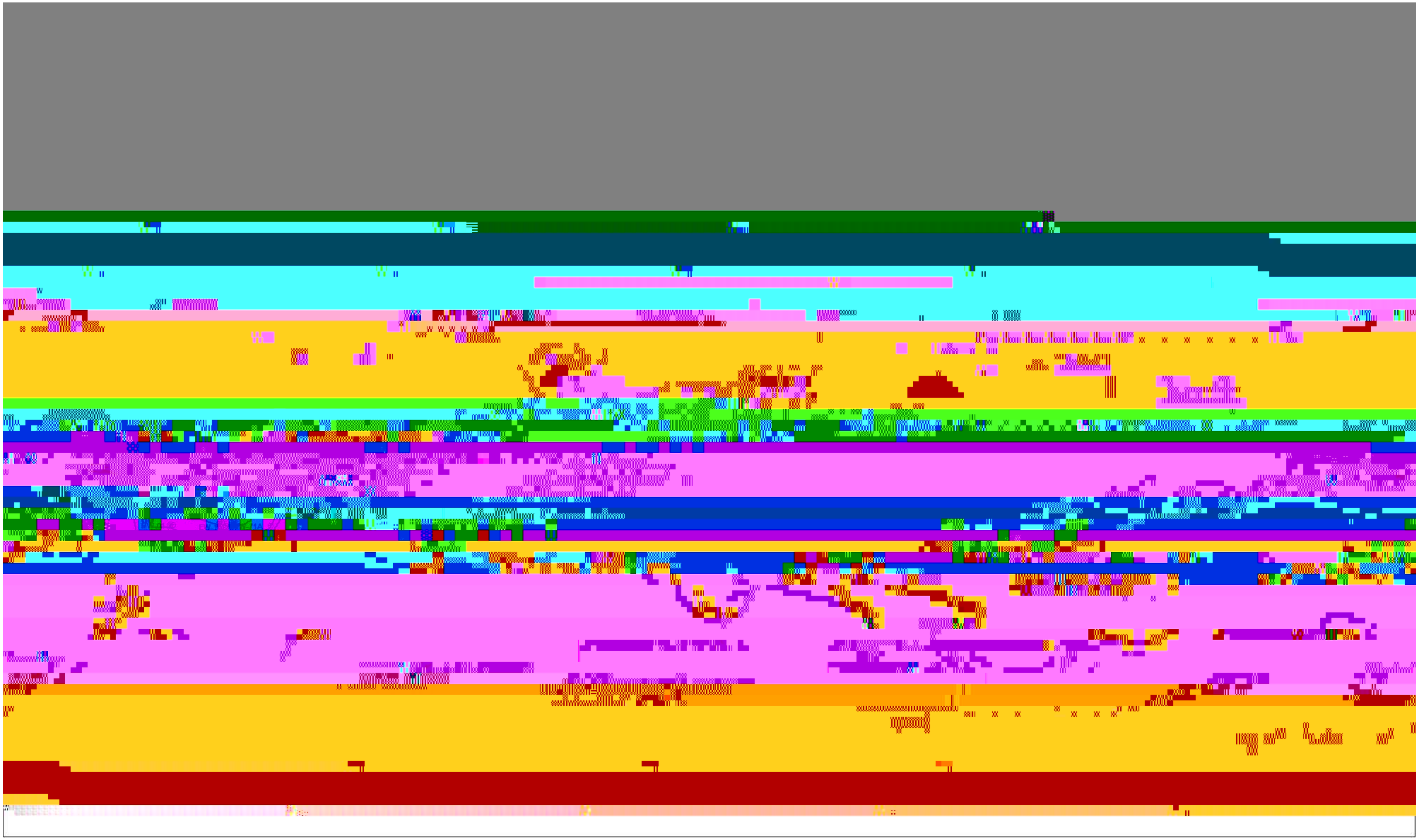

Beaumont Site 1

10

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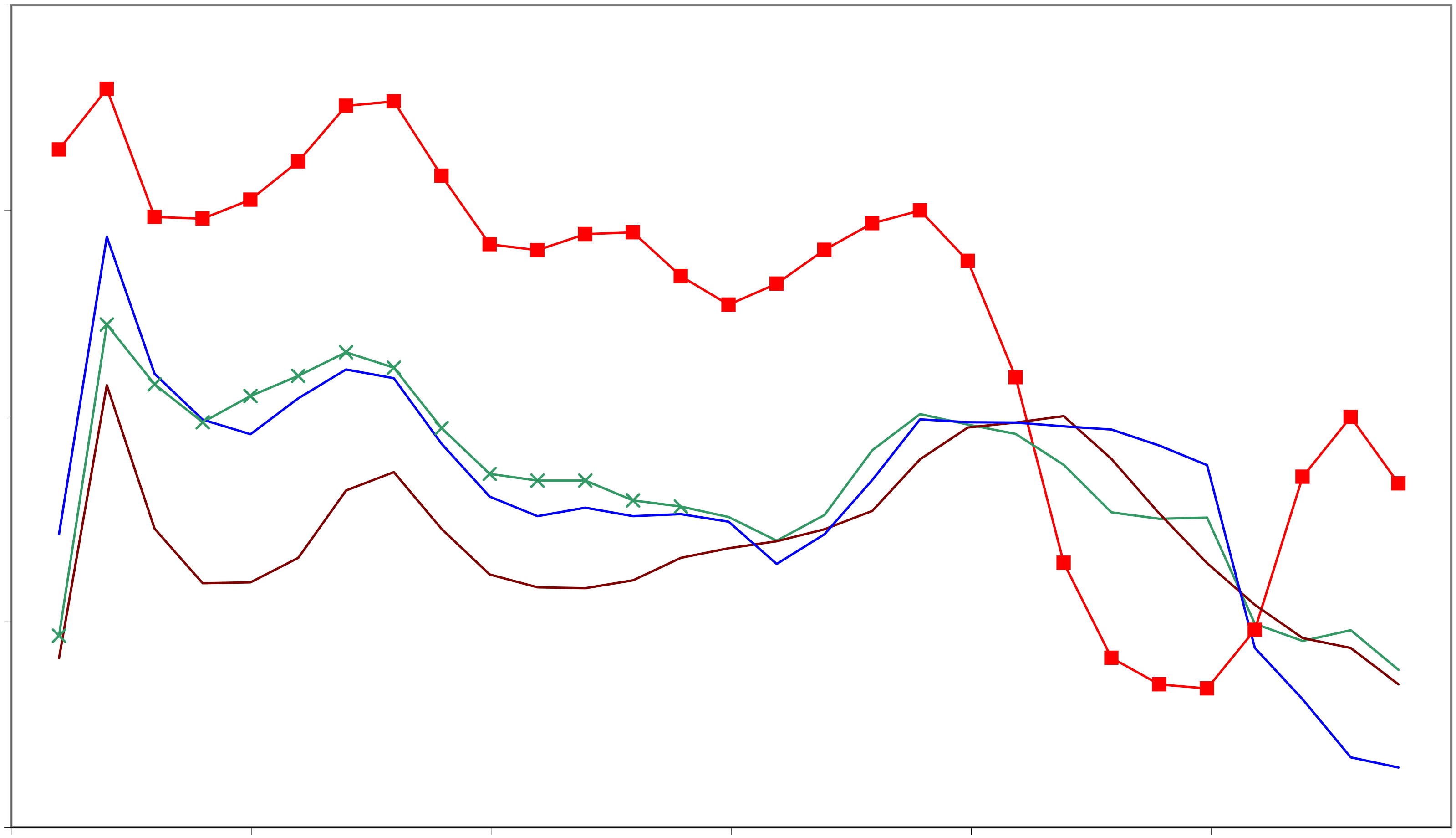

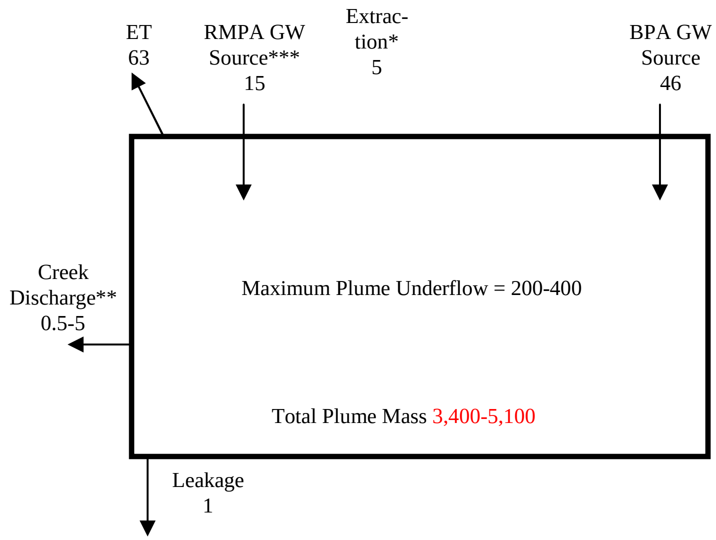

Figure 12. COC Mass Flux Diagrams