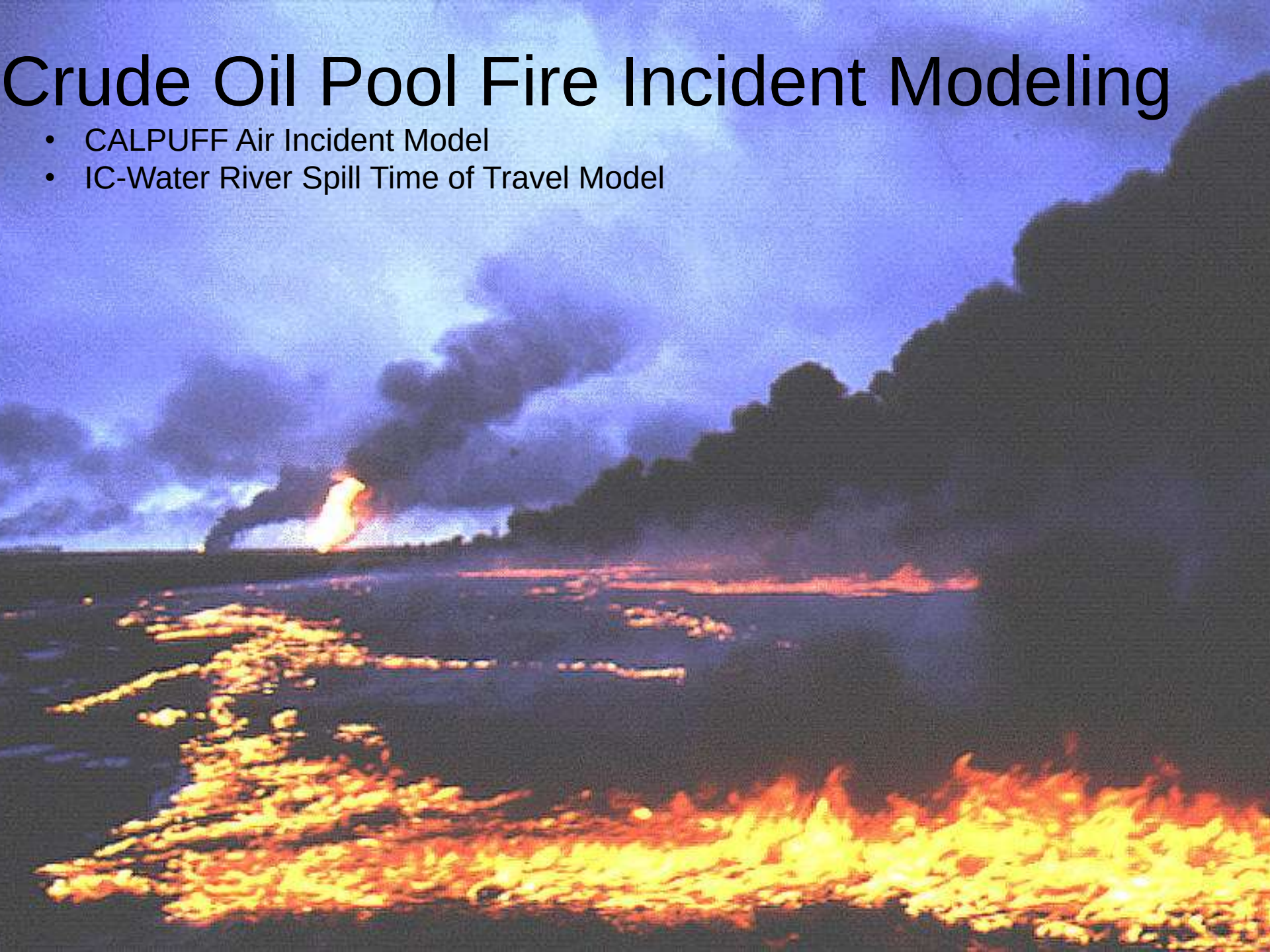
Crude Oil Pool Fire Incident Modeling

- CALPUFF Air Incident Model
- IC-Water River Spill Time of Travel Model



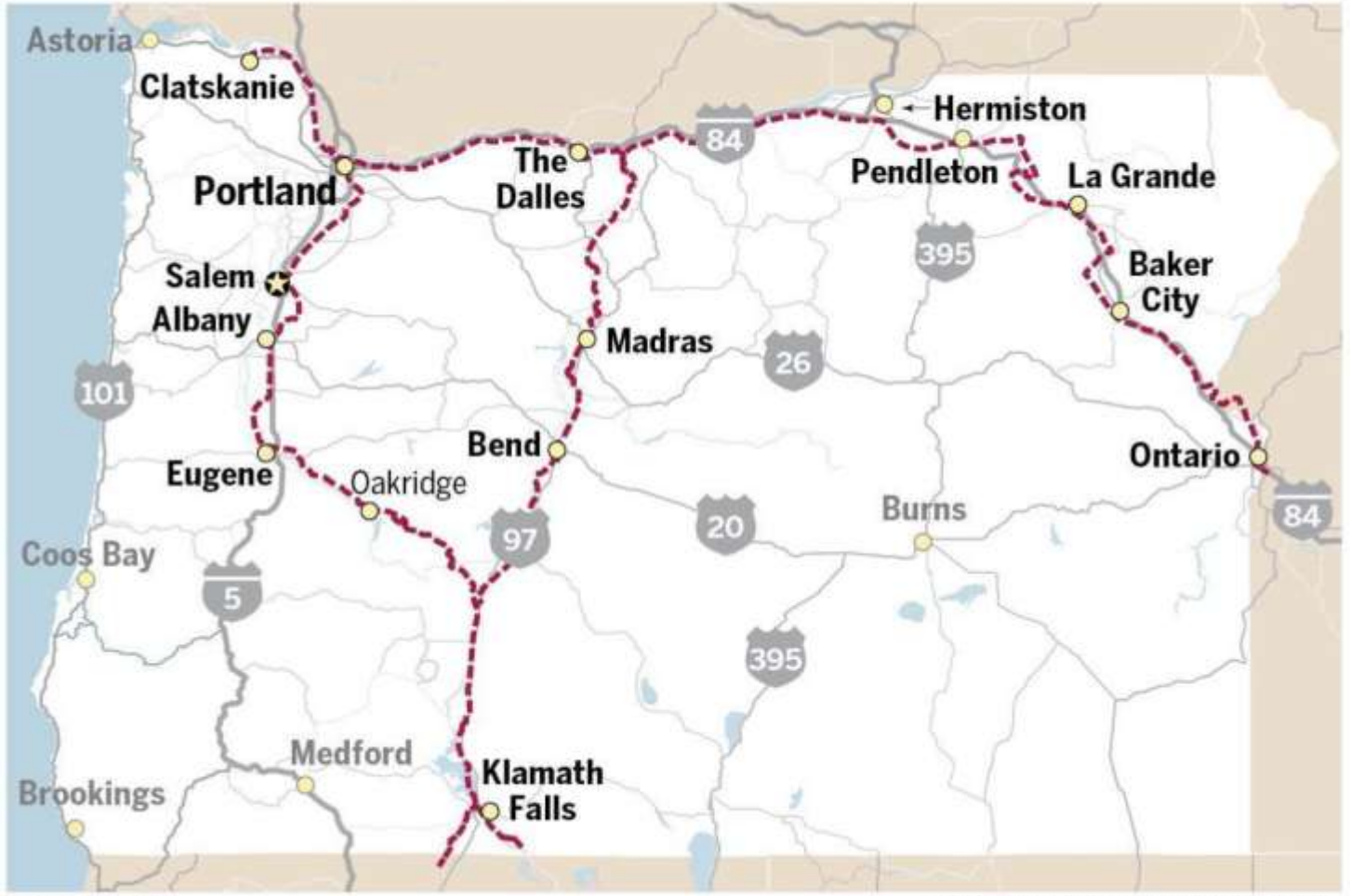
Conclusions

- Crude Oil Pool fires produce smoke plumes and contaminated water bodies.
- Some crude recently being transported in our region is more volatile and susceptible to fires if spilled.
- Idaho DEQ has added Bakken Crude Pool fire scenarios to our Calpuff Incident Model and IC-Water time of travel river spill model.
- Our domain is the NW Region and we may be able to assist others if an accident occurs.


N

Crude-by-Rail Facilities Map

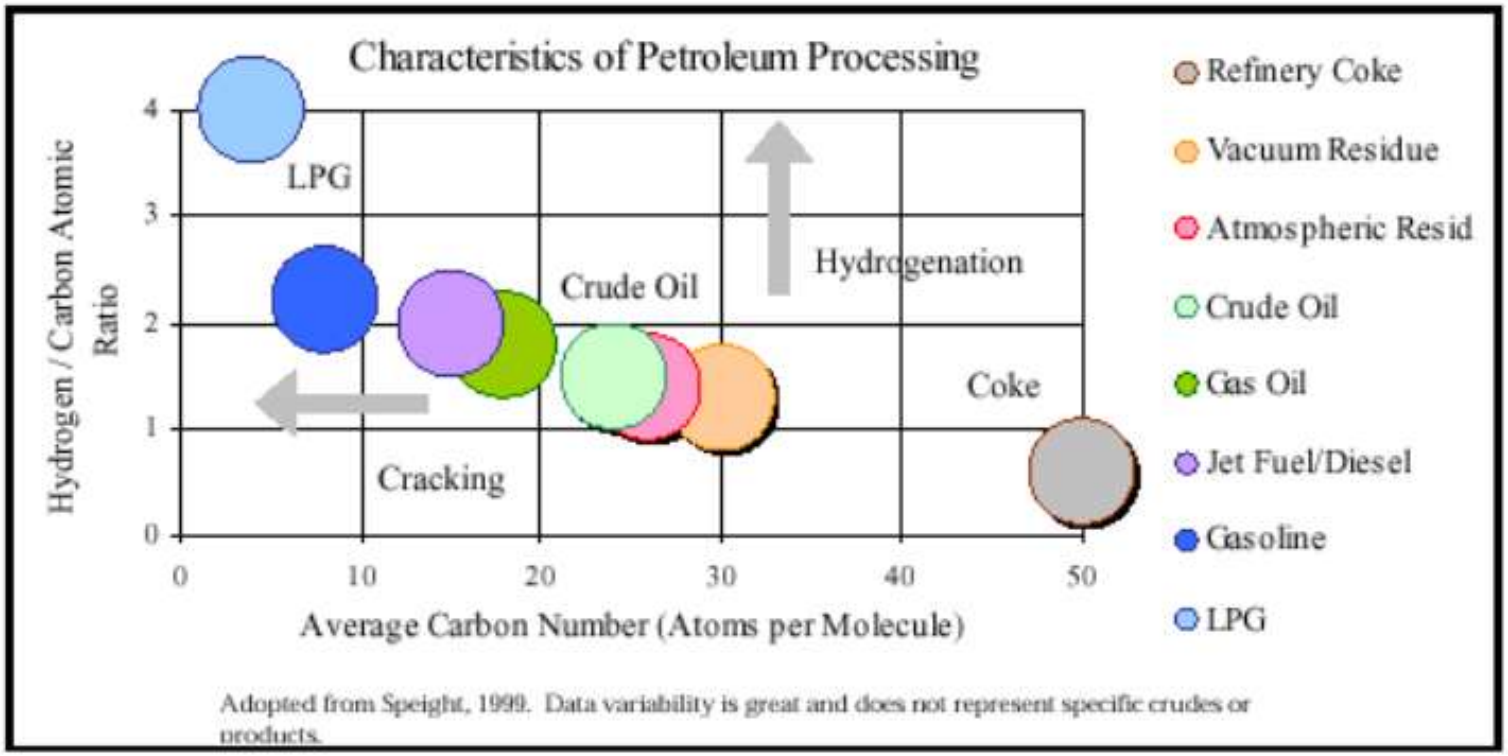
Oregon's oil train routes



Source: ODOT

DAN AGUAYO/THE OREGONIAN

Characteristics of Petroleum Products



Adopted from Speight, 1999. Data variability is great and does not represent specific crudes or products.

Refining Overview – Petroleum Processes & Products,
by Freeman Self, Ed Ekholm, & Keith Bowers, AIChE CD-ROM, 2000

Feb. 23, 2014 7:10 p.m. ET

Under Pressure

Investigators are looking into how fast North Dakota crude emits gases and how that contributes to oil-train explosions.

Select types of crude oil that are commonly run in U.S. refineries, by average Reid Vapor Pressure*

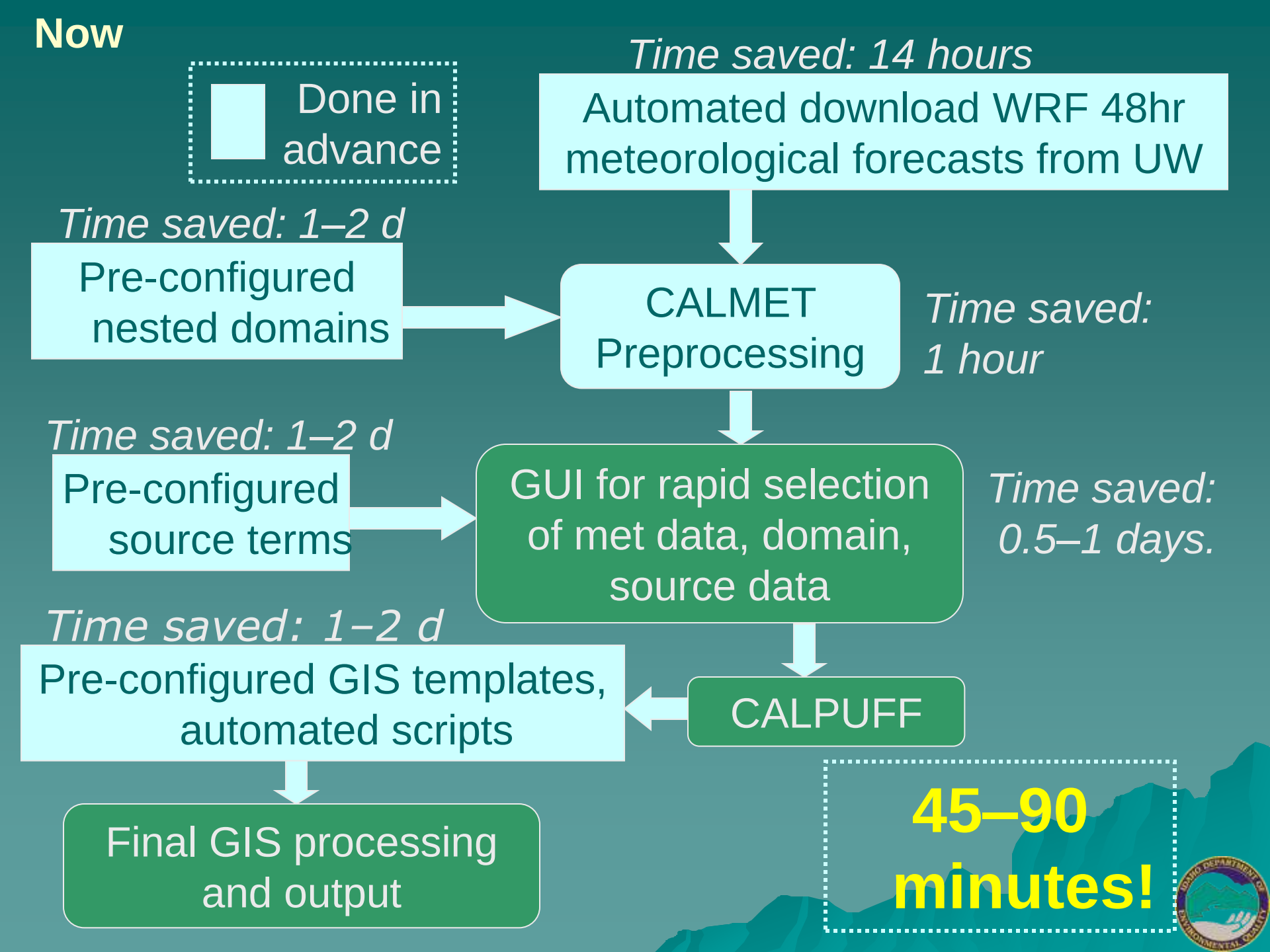
*Reid Vapor Pressure is a common measurement of how quickly a liquid fuel evaporates and emits gases.

Source: Wall Street Journal analysis of Capline Pipeline data

The Wall Street Journal

Calpuff **I**ncident **M**odeling **S**ystem for Air Releases

R. Hardy, W. Zhang, S. Strachan


Now
Done in advance
Time saved: 14 hours
Automated download WRF 48hr meteorological forecasts from UW
Time saved: 1–2 d
Pre-configured nested domains
CALMET Preprocessing
Time saved: 1 hour
Time saved: 1–2 d
Pre-configured source terms
GUI for rapid selection of met data, domain, source data
Time saved: 0.5–1 days.
Time saved: 1–2 d
Pre-configured GIS templates, automated scripts
CALPUFF
Final GIS processing and output
45–90 minutes!

Preconfigured Source Terms:

264 starting scenarios in 13 Categories

Category	SubCategory
Aerial Dispersal	
Explosive Dispersal	
Industrial Spill	Catastrophic
Industrial Spill	Pipe Break
Industrial Spill	Stack Release
Pool Fire	
Rail Transport Spill	Catastrophic
Rail Transport Spill	Pipe Break
Volatiles in River	
Truck Transport Spill	Catastrophic
Truck Transport Spill	Pipe Break
Warehouse Fire	
Wastepile Fire	

Source Term Example: Industrial Catastrophic

Table for Industrial-Catastrophic					
Hazardous Material	Species	Quantity (lbs)	Hole size (inches)	Release Rate (lb/min)	Duration (min)
Anhydrous Ammonia (liq)	NH3	1220000	20.4	160000	7.6
Anhydrous Ammonia (liq)	NH3	1080000	15	158000	6.8
Anhydrous Ammonia (liq)	NH3	600000	15	78900	7.6
Anhydrous Ammonia (liq)	NH3	300000	11	38800	7.7
Anhydrous Ammonia (liq)	NH3	160000	8	19000	8.4
Anhydrous Ammonia (liq)	NH3	70000	6	10100	6.9
Anhydrous Ammonia (liq)	NH3	12000	2.5	1430	8.4
Chlorine Gas (liq)	CL2	1080000	7.8	108000	10.0
Chlorine Gas (liq)	CL2	60000	2	3080	19.5
Chlorine Gas (liq)	CL2	24000	1.25	2630	9.1
Chlorine Gas (liq)	CL2	8000	0.7	821	10.0
Anhydrous SO2 (liq)	SO2	14000	1.15	1460	10.0
Aqueous Ammonia > 20%	NH3	160000	pool	2400	60.0
Aqueous Ammonia > 20%	NH3	74000	pool	1150	60.0
Aqueous Ammonia > 20%	NH3	24000	pool	1088	60.0
Hydrochloric acid > 38%	HCL	27743	pool	712	60.0
Chlorine Dioxide	CLO2	36350	3	5180	9.0
Carbon Disulfide	CS2	3500000	20	40500	60.0
Mono-Methyl Amine	MMA	350000	7	34400	11.0

CHAPTER 3. ESTIMATING BURNING CHARACTERISTICS OF LIQUID POOL FIRE, HEAT RELEASE RATE, BURNING DURATION, AND FLAME HEIGHT

Version 1805.0

The following calculations estimate the heat release rate, burning duration, and flame height for liquid pool fire.
Parameters in YELLOW CELLS are Entered by the User.
Parameters in GREEN CELLS are Automatically Selected from the DROP DOWN MENU for the Fuel Selected.
All subsequent output values are calculated by the spreadsheet and based on values specified in the input parameters. This spreadsheet is protected and secure to avoid errors due to a wrong entry in a cell(s).
The chapter in the NUREG should be read before an analysis is made.

INPUT PARAMETERS

Fuel Spill Volume (V)	2438.00	gallons	9.2288 m^3
Fuel Spill Area or Dike Area (A_{dike})	3,910	ft^2	363.251 m^2
Mass Burning Rate of Fuel (m")	0.06	kg/m^2-sec	
Effective Heat of Combustion of Fuel ($\Delta H_{c,eff}$)	42700	kJ/kg	
Fuel Density (ρ)	816.6	kg/m^3	
Empirical Constant ($k\beta$)	2.8	m^{-1}	
Ambient Air Temperature (T_a)	77.00	°F	25.00 °C
			298.00 K
Gravitational Acceleration (g)	9.81	m/sec^2	
Ambient Air Density (ρ_a)	1.18	kg/m^3	

Calculate

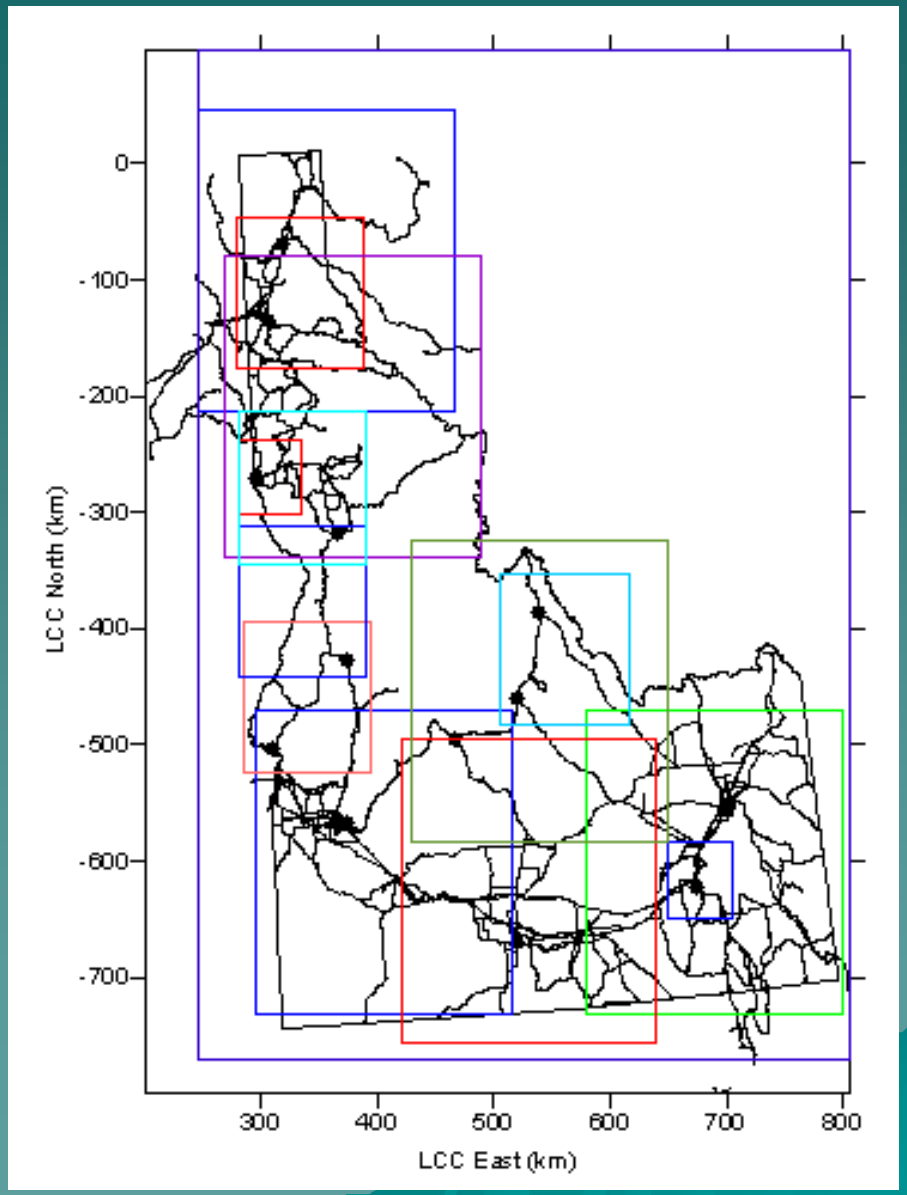
Note: Air density will automatically correct with Ambient Air Temperature (T_a) Input

Preliminary Bakken Crude Pool Fire Scenarios

Pool Fire Source Scenarios	Area, ft2	Vol (gal)	Mass Burn Rate	HRR, kW
10% of Avg Spill pooled 6 in deep	65	244	0.045 kg/m2-s	11,598
Average Rail Spill-pooled 6 in deep	652	2,438	0.045 kg/m2-s	116,391
1 DOT 111 car-pooled 6 in deep	8,021	30,000	0.045 kg/m2-s	1,431,854
3 DOT-111 cars - pooled 6 in deep	24,066	90,015	0.045 kg/m2-s	4,296,098
10 DOT-111 cars - pooled 6 in deep	80,208	300,000	0.045 kg/m2-s	14,318,186
33 DOT-111 cars - pooled 6 in deep	267,360	1,000,000	0.045 kg/m2-s	47,727,287
10% of Avg Spill pooled 2 ft deep	16	244	0.045 kg/m2-s	2,796
Average Rail Spill-pooled 2 ft deep	163	2,438	0.045 kg/m2-s	29,098
1 DOT 111 car-pooled 2 ft deep	2,005	30,000	0.045 kg/m2-s	357,919
3 DOT-111 cars - pooled 2 ft deep	6,017	90,015	0.045 kg/m2-s	1,074,114
10 DOT-111 cars - pooled 2 ft deep	20,052	300,000	0.045 kg/m2-s	3,579,547
33 DOT-111 cars - pooled 2 ft deep	66,840	1,000,000	0.045 kg/m2-s	11,931,822
10% of Avg Spill pooled 1 in on water	391	244	0.06 kg/m2-s	93,065
Average Rail Spill-pooled 1 in on water	3,910	2,440	0.06 kg/m2-s	930,649
1 DOT 111 car-pooled 1 in on water	48,125	30,000	0.06 kg/m2-s	11,454,596
3 DOT-111 cars - pooled 1 in on water	144,398	90,000	0.06 kg/m2-s	34,369,740
10 DOT-111 cars - pooled 1 in on water	481,248	300,000	0.06 kg/m2-s	114,545,488
33 DOT-111 cars - pooled 1 in on water	1,604,160	1,000,000	0.06 kg/m2-s	381,818,295

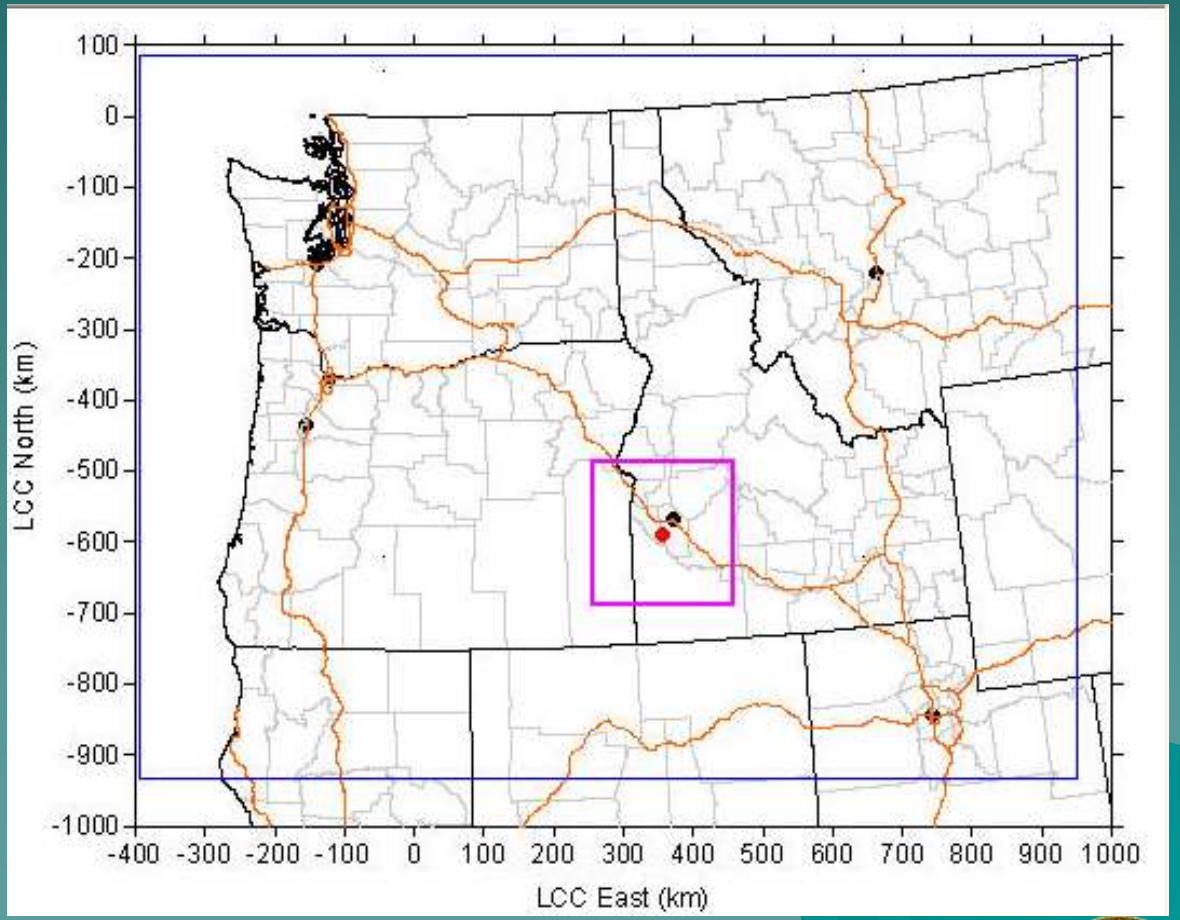
Idaho Modeling Domains and Resolution

- id_4km
- CDA_1km
- CDA_500m
- Lewiston_1km
- Lewiston_500m
- Lewiston_250m
- Riggins_500m
- McCall_500m
- Boise_1km
- TwinFalls_1km
- Salmon_1km
- Salmon_500m
- Pocatello_1km
- Pocatello_250m

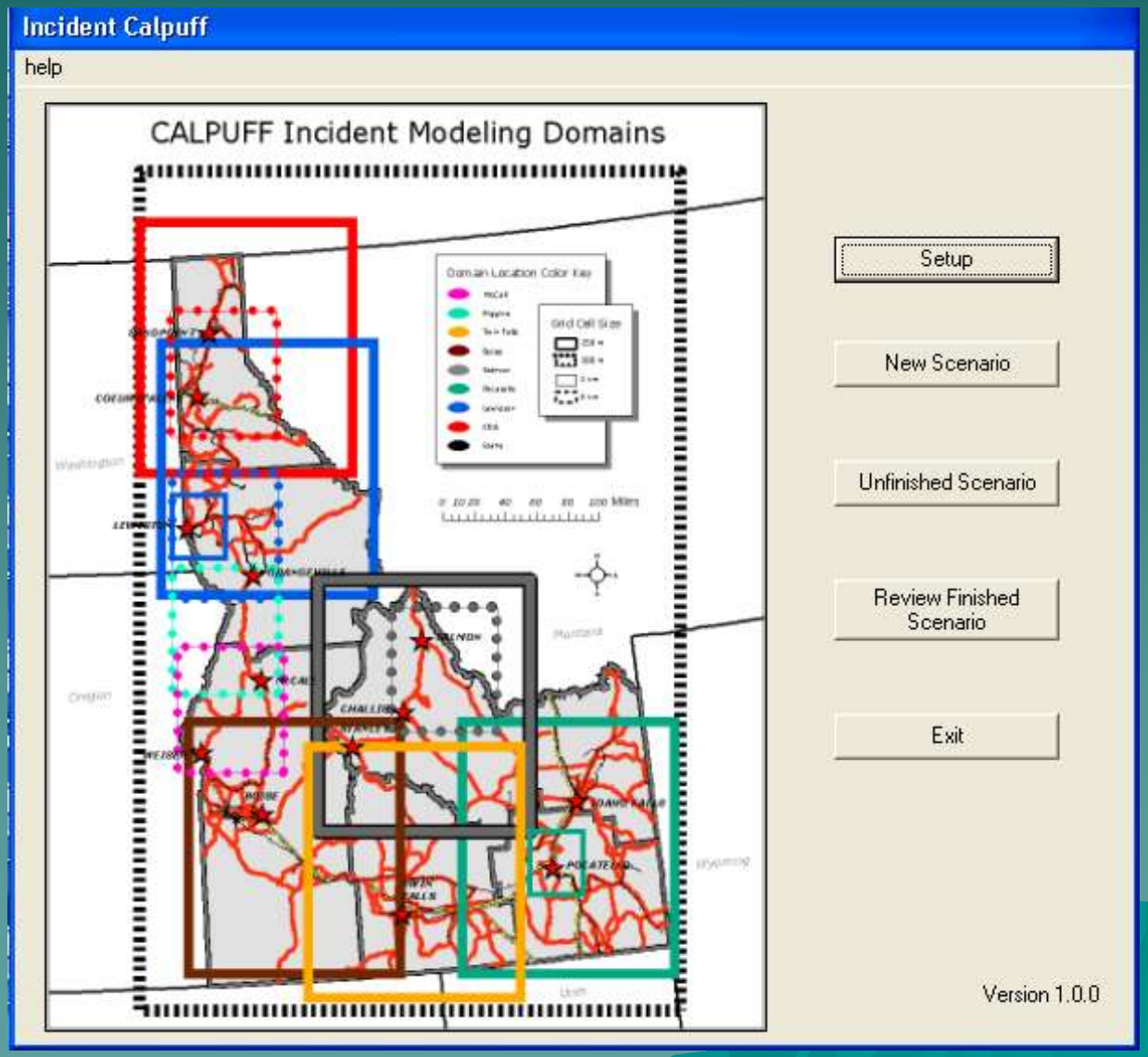


Expanded Geographic Coverage

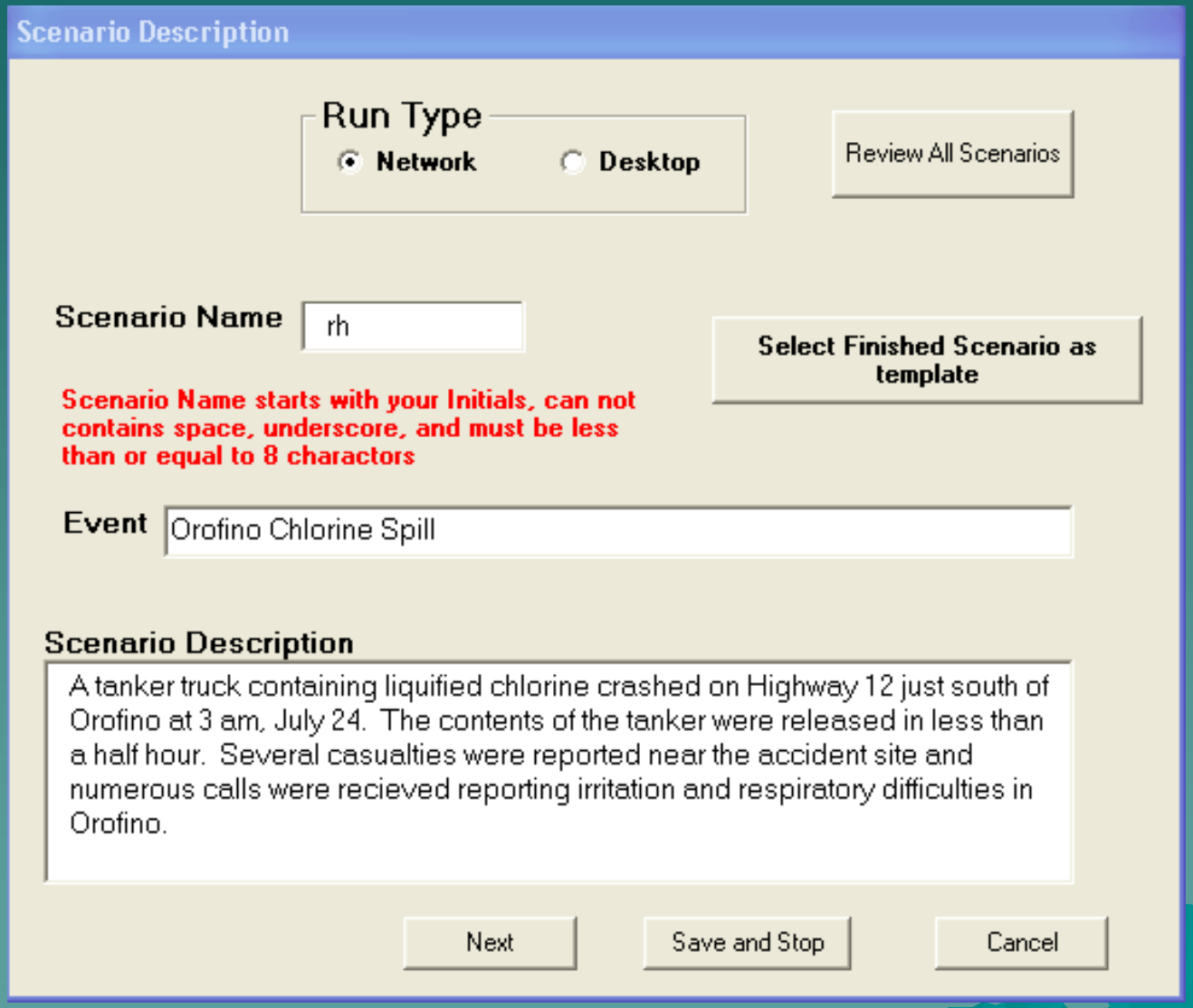
- Added 4 km Pacific Northwest domain
- Pacific coast to western MT and WY
- Lower Fraser River valley, BC, to Salt Lake City, UT
- Allows Idaho to model releases outside of Idaho that might affect us (*e.g.*, large fires, FMD)



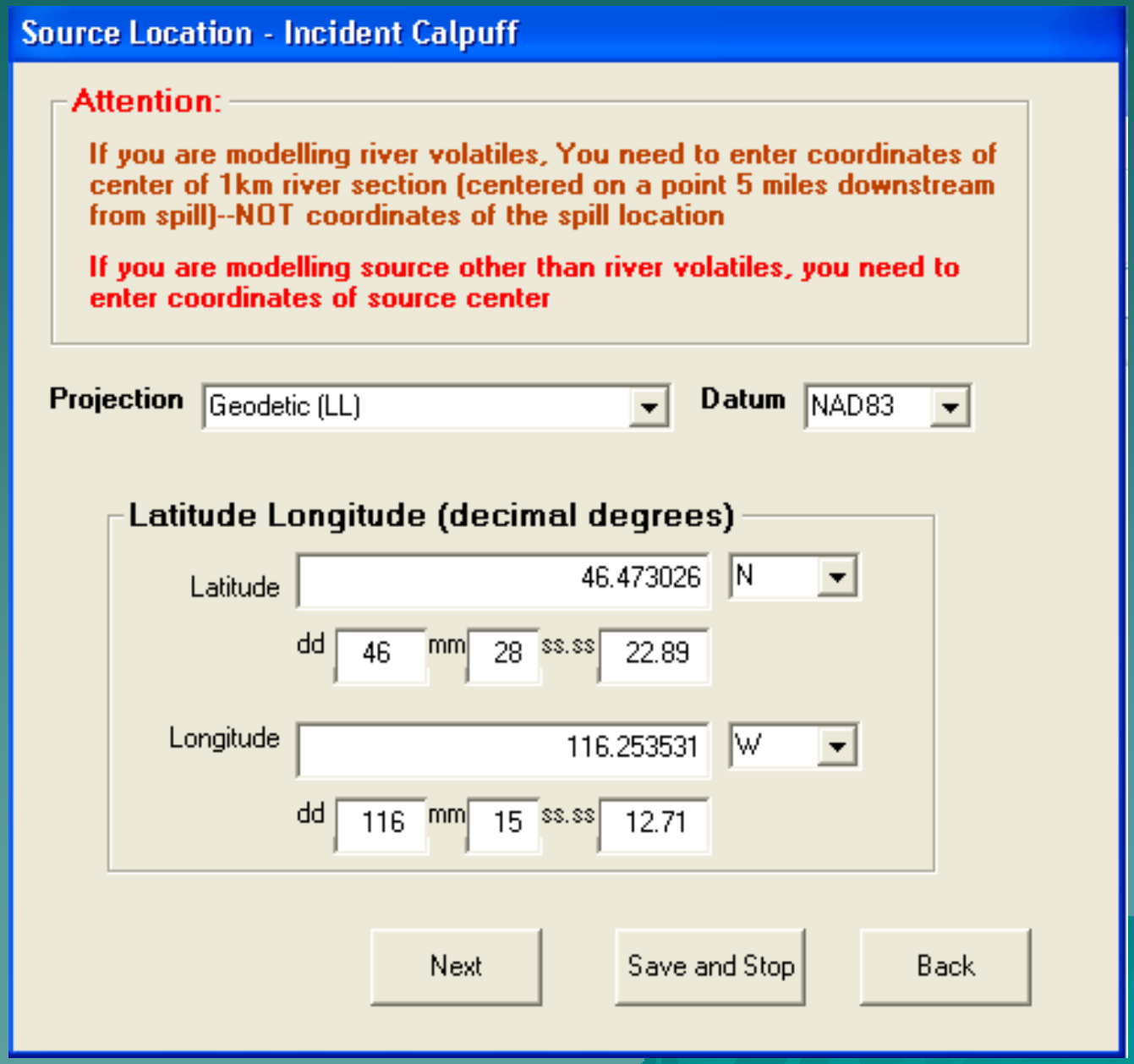
Graphical User Interface



Enter Scenario Name and Description



Enter Source Coordinates

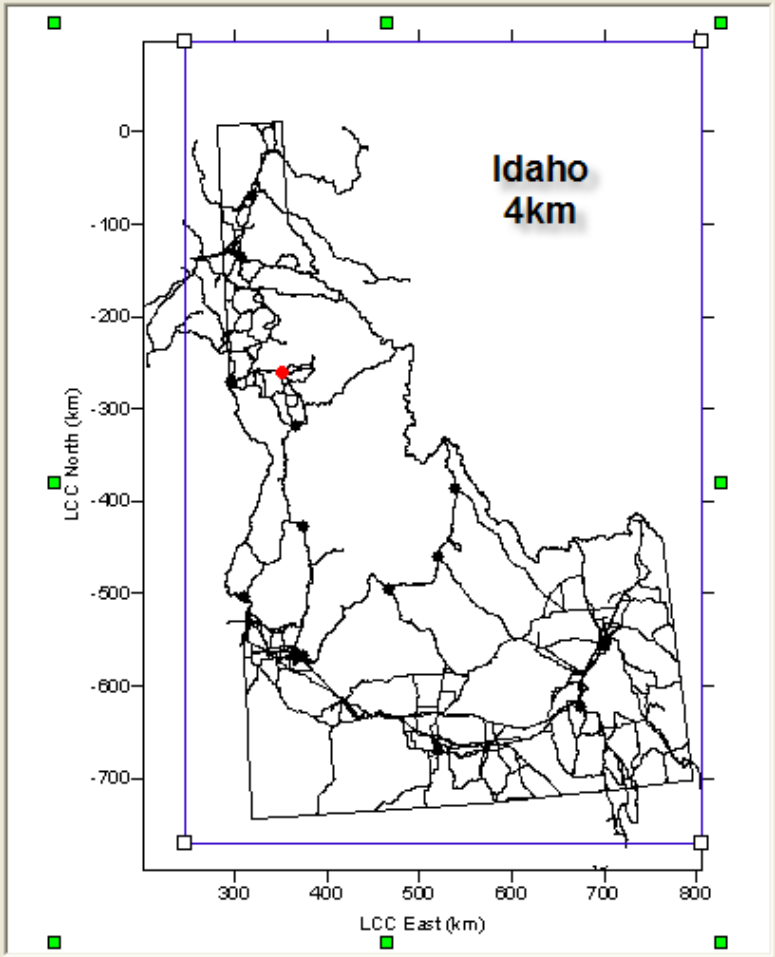


Select Domain and Resolution

Select Domain

Select Domain from the table below: **Selected Domain** idaho_4km

	Domain_No	Domain_Name	Short_Name	Grid_Origin_X	Grid_Origin_Y	Grid_Spacing	NX	NY
▶	0	idaho_4km	id_4km	246	-770	4	140	217
	2	lewiston_1km	lew_1km	268	-339	1	220	260
	12	lewiston_500m	lew_500m	280	-344	0.5	220	260



Legend

Source Location

Datum and LCC (km)

Datum: NAD83

	X Easting:	Y Northing:
Source Location:	351.877	-261.105
Offset:	0	0

Origin of Projection (decimal degrees):

Latitude: 49 Longitude: -121

Matching Latitudes (decimal degrees):

Latitude 1: 30 Latitude 2: 60

Distance from Domain Edge (km)

West 105.877 East 454.123

South 508.895 North 359.105

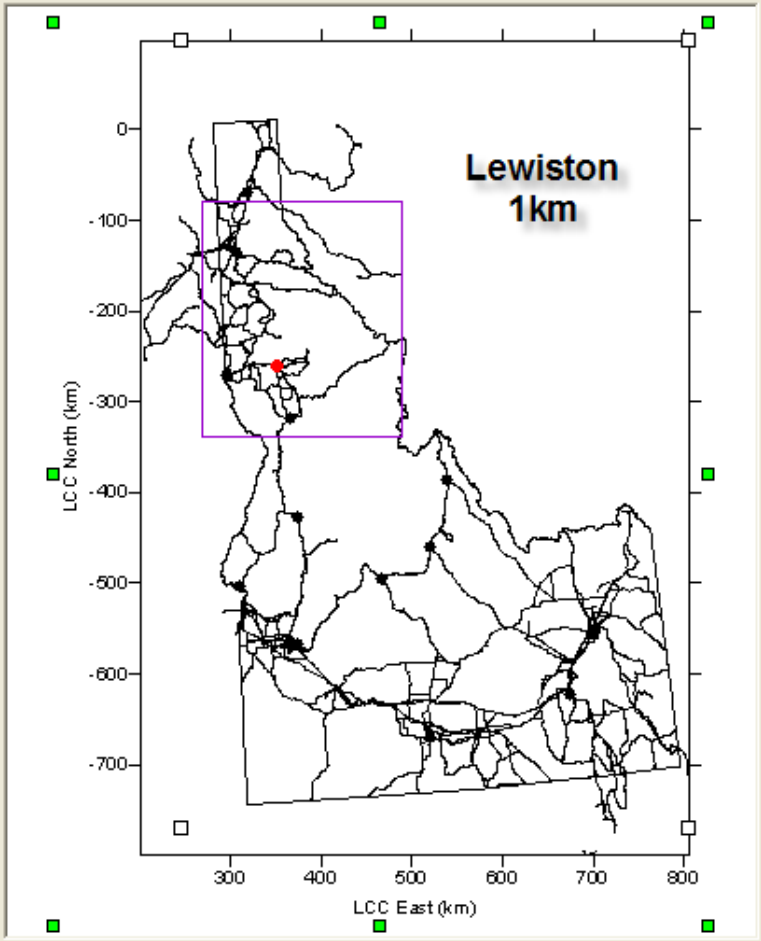
Next | Save and Stop | Back

Lewiston: 1km Resolution

Select Domain

Select Domain from the table below: **Selected Domain** lewiston_1km

	Domain_No	Domain_Name	Short_Name	Grid_Origin_X	Grid_Origin_Y	Grid_Spacing	NX	NY
	0	idaho_4km	id_4km	246	-770	4	140	217
▶	2	lewiston_1km	lew_1km	268	-339	1	220	260
	12	lewiston_500m	lew_500m	280	-344	0.5	220	260



Legend

Source Location

Datum and LCC (km)

Datum: NAD83

	X Easting:	Y Northing:
Source Location:	351.877	-261.105
Offset:	0	0

Origin of Projection (decimal degrees):

Latitude: 49 Longitude: -121

Matching Latitudes (decimal degrees):

Latitude 1: 30 Latitude 2: 60

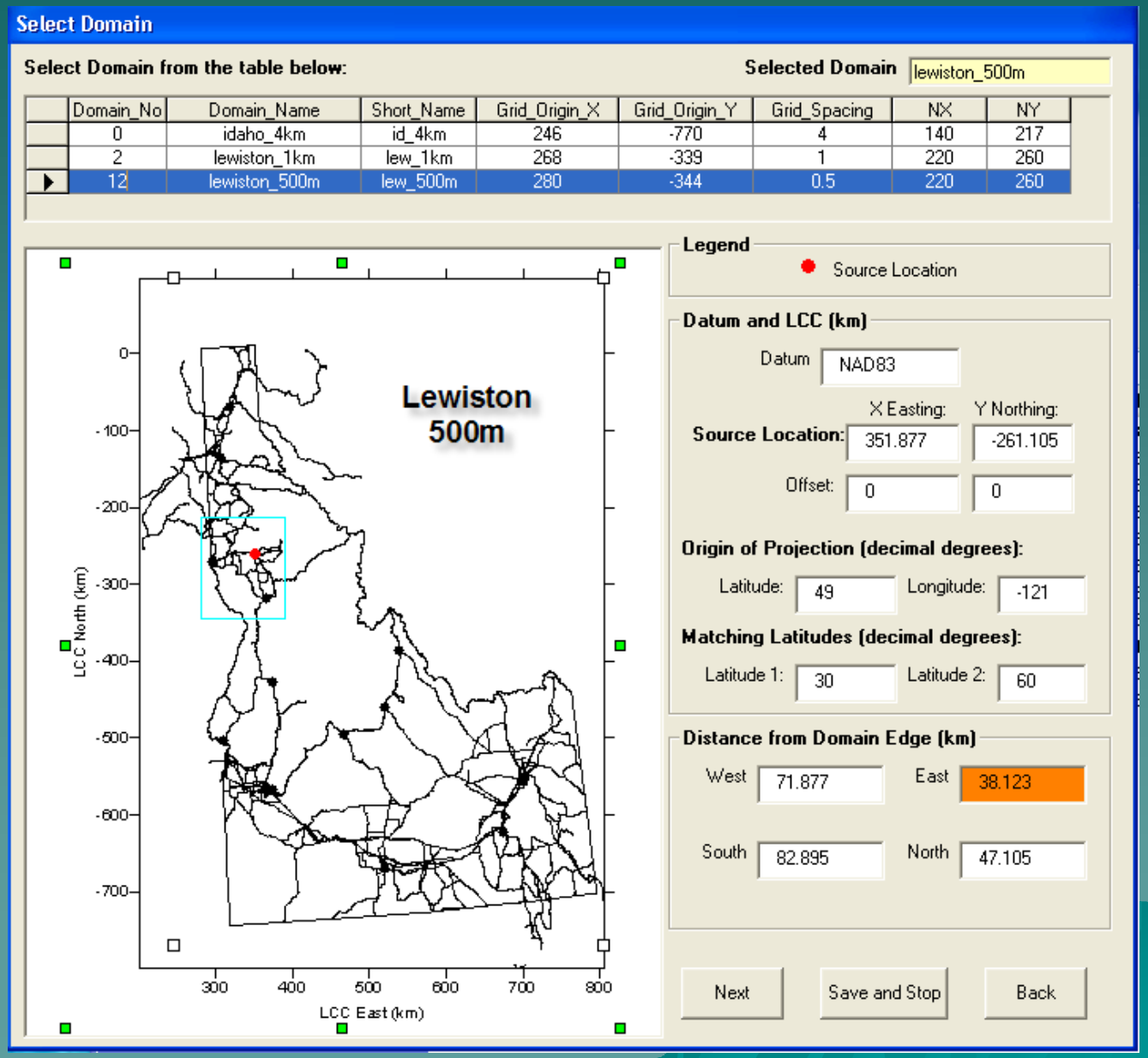
Distance from Domain Edge (km)

West 83.877 East 136.123

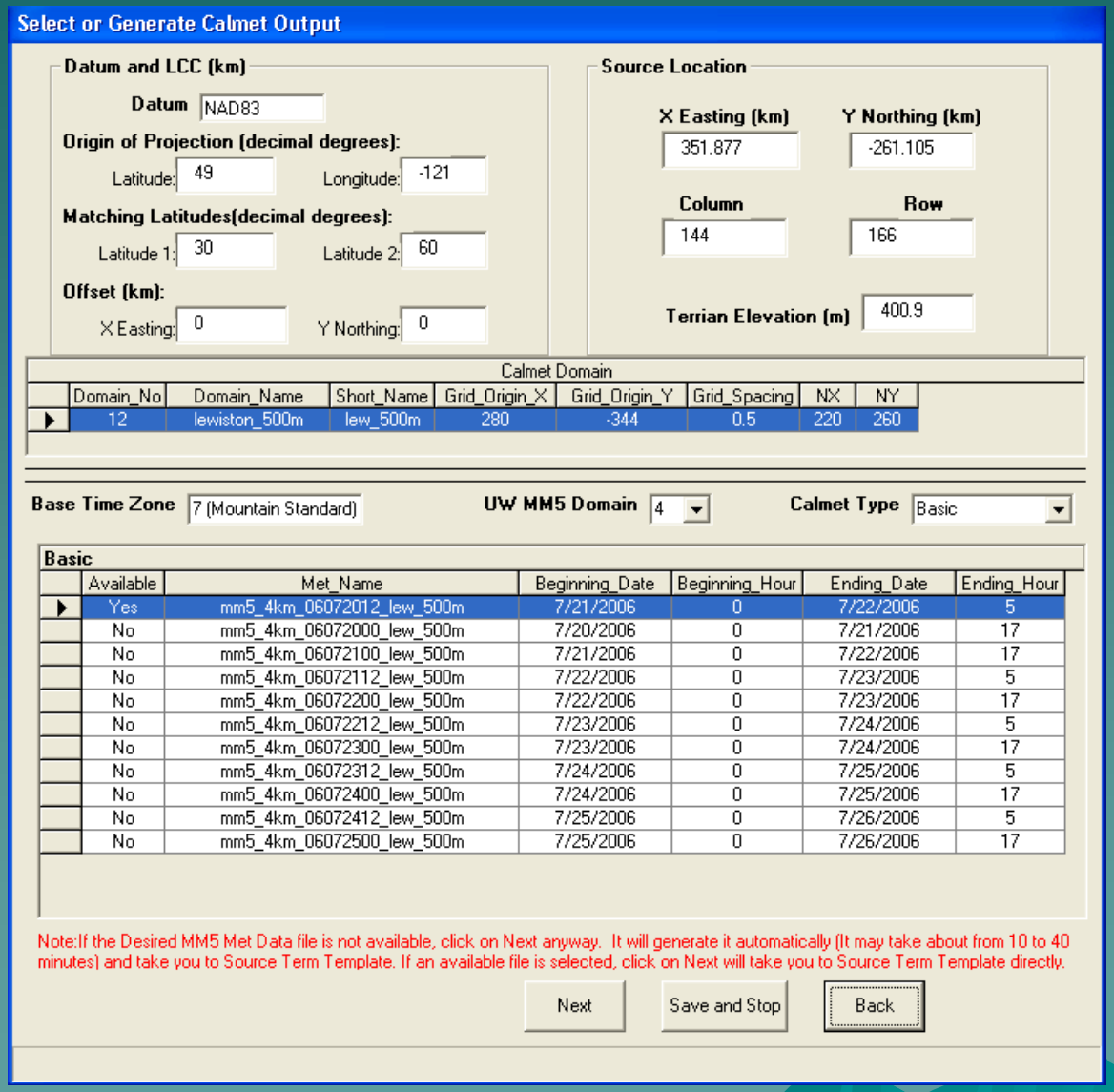
South 77.895 North 182.105

Next | Save and Stop | Back

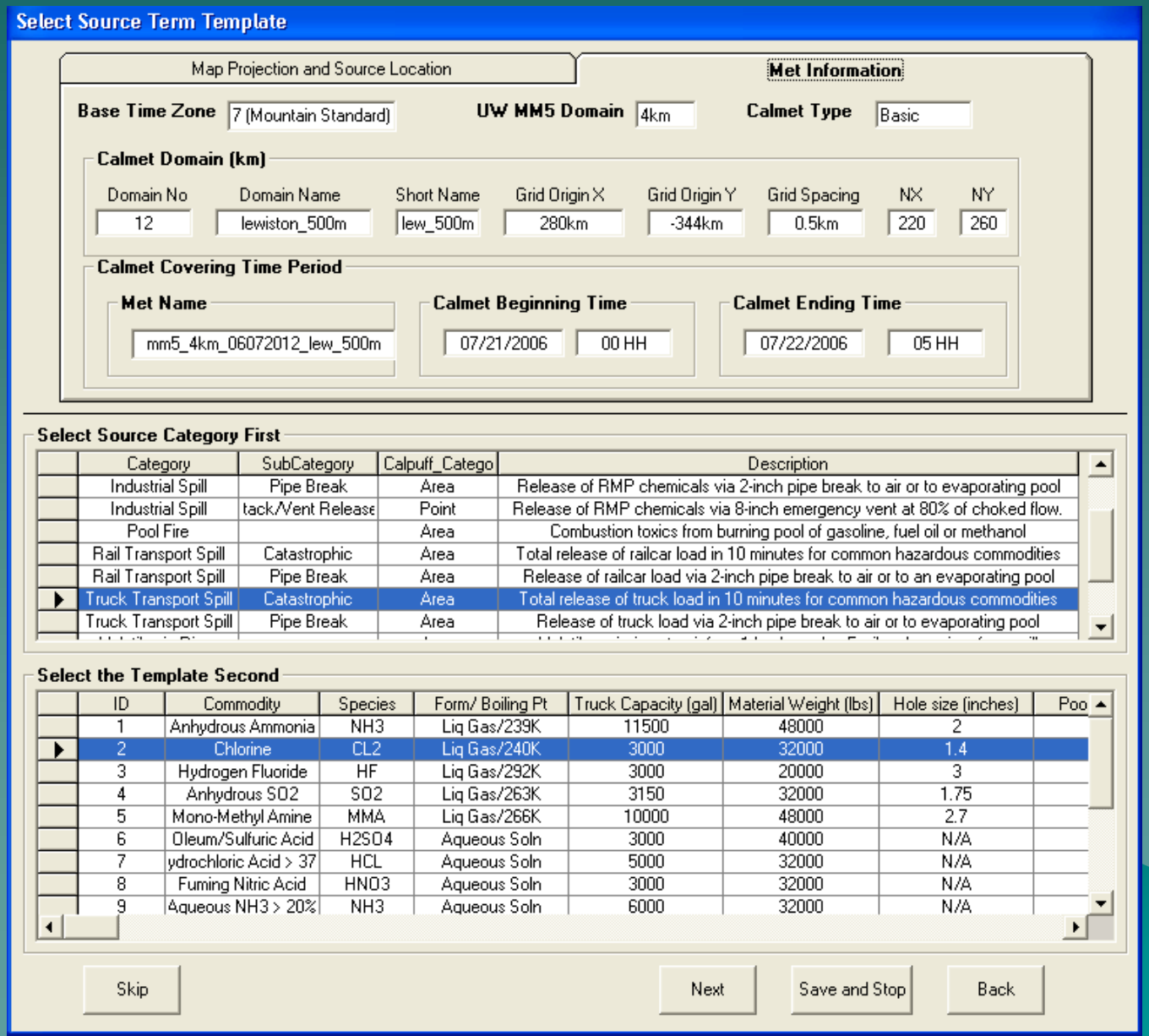
Lewiston: 500m Resolution



Select Meteorology File



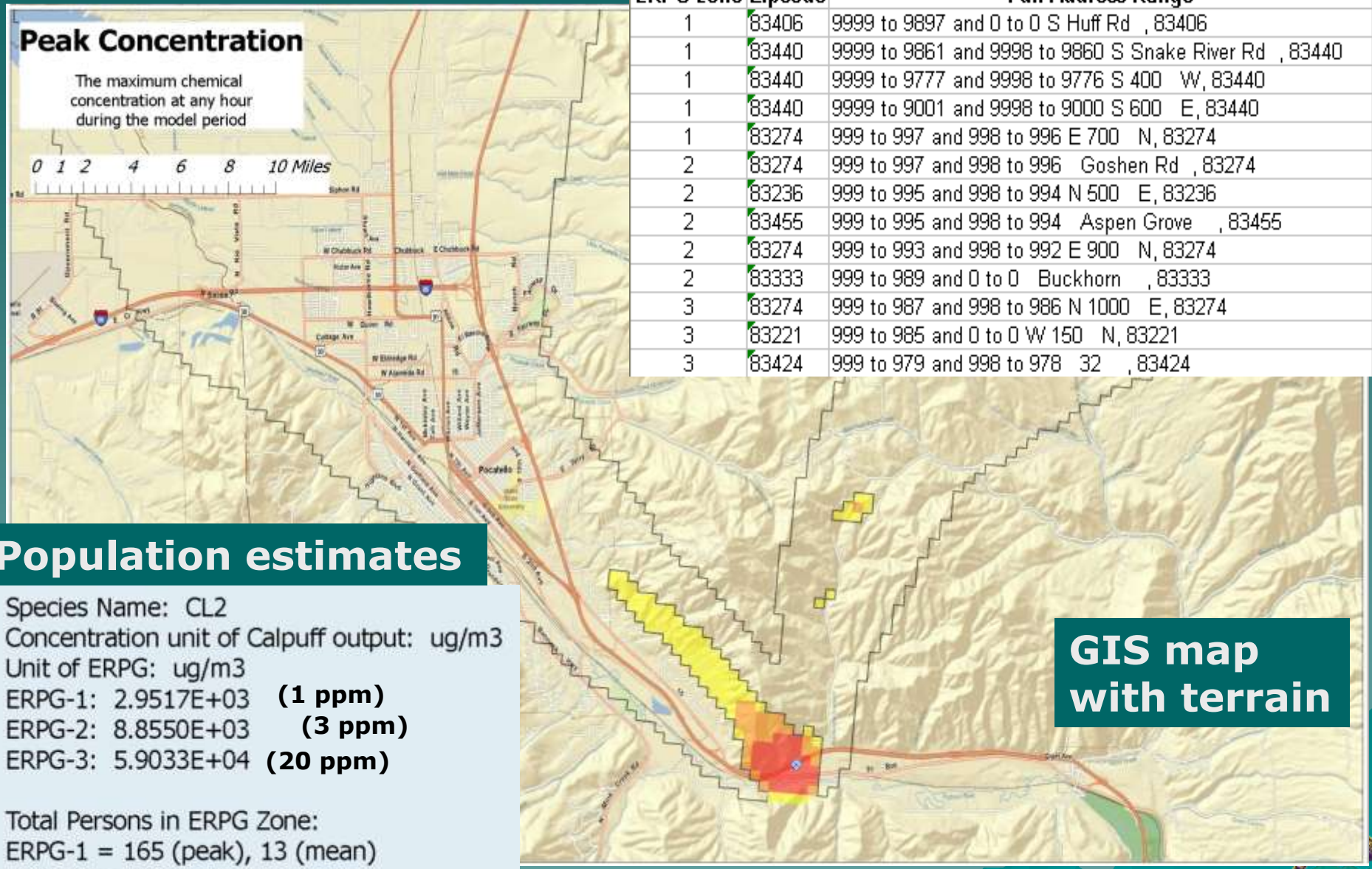
Select Source Category and Template



GIS Outputs

Address ranges for zones

ERPG zone	Zipcode	Full Address Range
1	83406	9999 to 9897 and 0 to 0 S Huff Rd , 83406
1	83440	9999 to 9861 and 9998 to 9860 S Snake River Rd , 83440
1	83440	9999 to 9777 and 9998 to 9776 S 400 W, 83440
1	83440	9999 to 9001 and 9998 to 9000 S 600 E, 83440
1	83274	999 to 997 and 998 to 996 E 700 N, 83274
2	83274	999 to 997 and 998 to 996 Goshen Rd , 83274
2	83236	999 to 995 and 998 to 994 N 500 E, 83236
2	83455	999 to 995 and 998 to 994 Aspen Grove , 83455
2	83274	999 to 993 and 998 to 992 E 900 N, 83274
2	83333	999 to 989 and 0 to 0 Buckhorn , 83333
3	83274	999 to 987 and 998 to 986 N 1000 E, 83274
3	83221	999 to 985 and 0 to 0 W 150 N, 83221
3	83424	999 to 979 and 998 to 978 32 , 83424



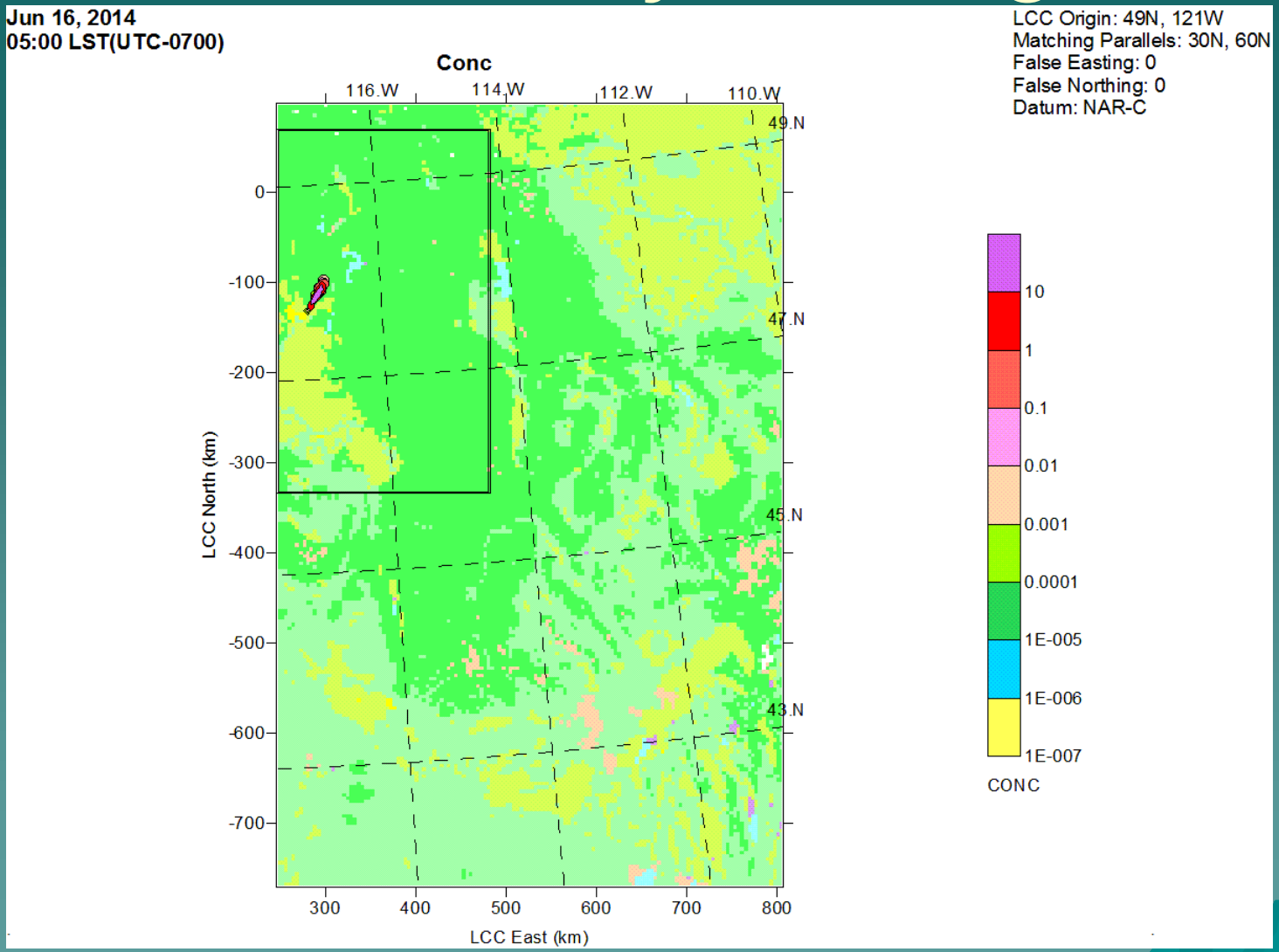
Population estimates

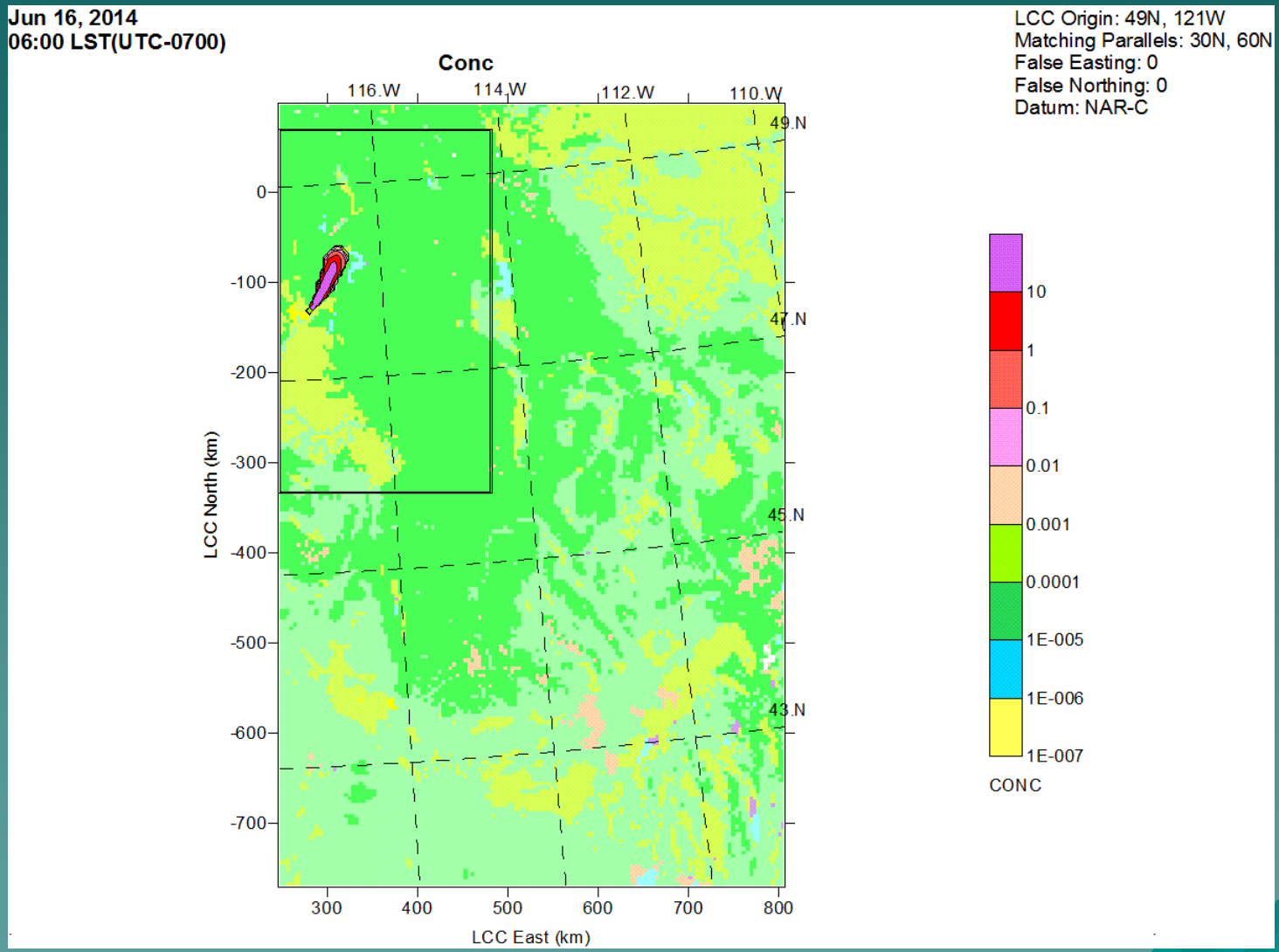
Species Name: CL2
Concentration unit of Calpuff output: ug/m3
Unit of ERPG: ug/m3
ERPG-1: 2.9517E+03 **(1 ppm)**
ERPG-2: 8.8550E+03 **(3 ppm)**
ERPG-3: 5.9033E+04 **(20 ppm)**

Total Persons in ERPG Zone:
ERPG-1 = 165 (peak), 13 (mean)
ERPG-2 = 50 (peak), 9 (mean)
ERPG-3 = 34 (peak), 13 (mean)

GIS map with terrain

Preliminary Testing

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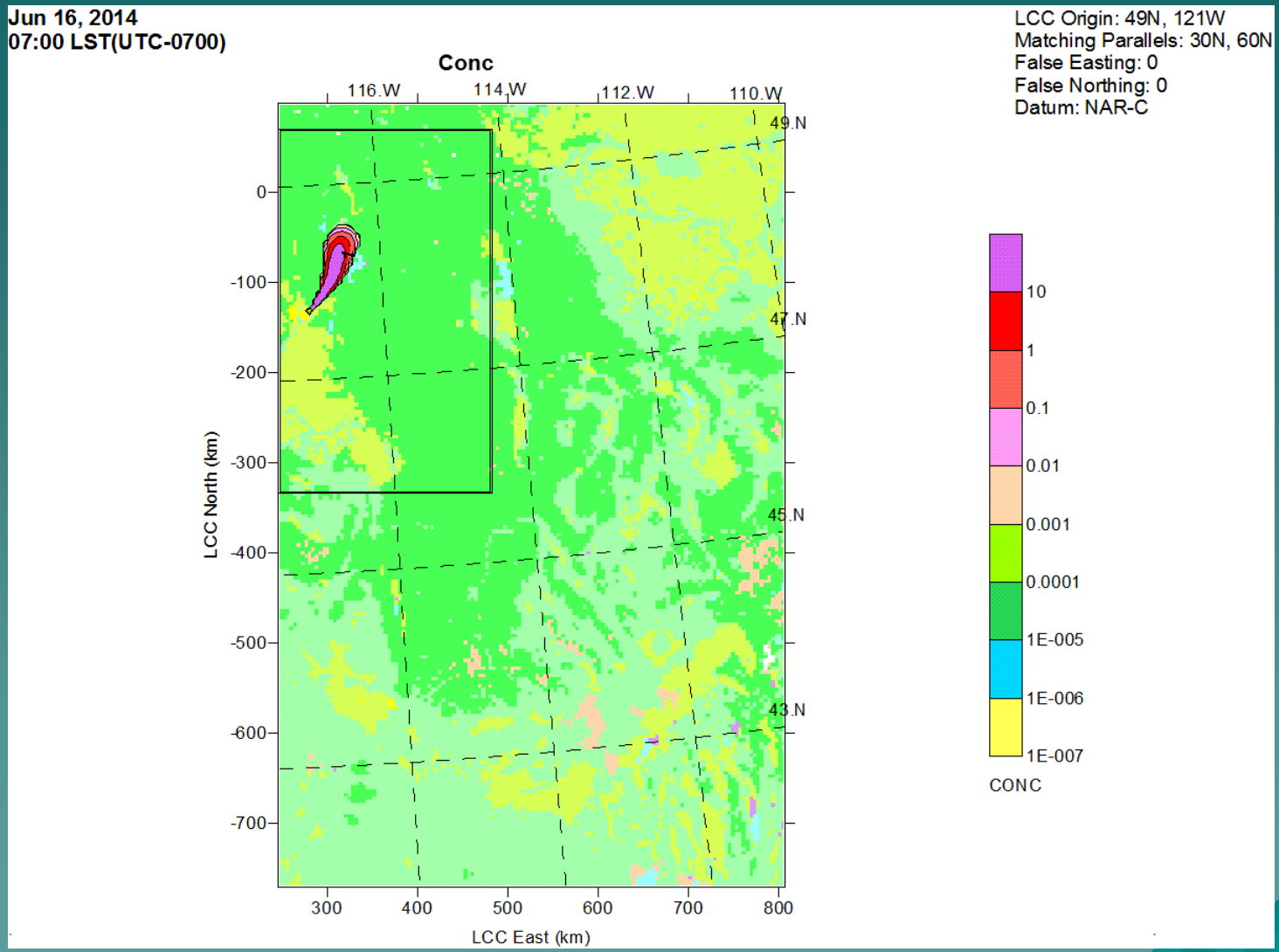
06:00 LST(UTC-0700)
Conc
116.W
114.W
112.W
110.W
49.N
47.N
45.N
43.N
0
-100
-200
-300
-400
-500
-600
-700
LCC North (km)
300
400
500
600
700
800
LCC East (km)
LCC Origin: 49N, 121W
Matching Parallels: 30N, 60N
False Easting: 0
False Northing: 0
Datum: NAR-C
10
1
0.1
0.01
0.001
0.0001
1E-005
1E-006
1E-007
CONC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False Northing: 0
Datum: NAR-C
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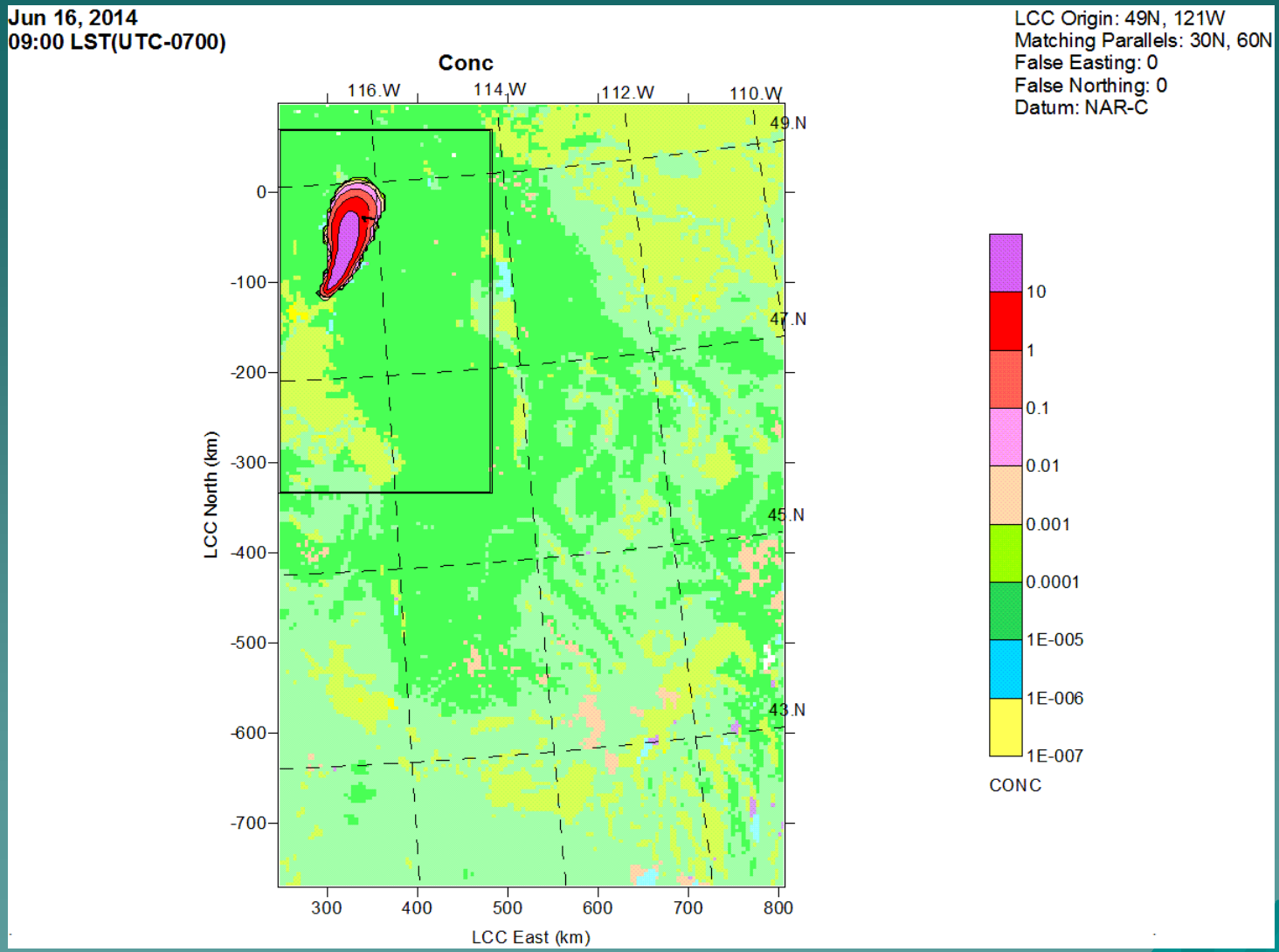
114.W
112.W
110.W
49.N
47.N
45.N
43.N
0
-100
-200
-300
-400
-500
-600
-700
LCC North (km)
300
400
500
600
700
800
LCC East (km)
10
1
0.1
0.01
0.001
0.0001
1E-005
1E-006
1E-007
CONC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-300
-400
-500
-600
-700
LCC North (km)
300
400
500
600
700
800
LCC East (km)
LCC Origin: 49N, 121W
Matching Parallels: 30N, 60N
False Easting: 0
False Northing: 0
Datum: NAR-C
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1
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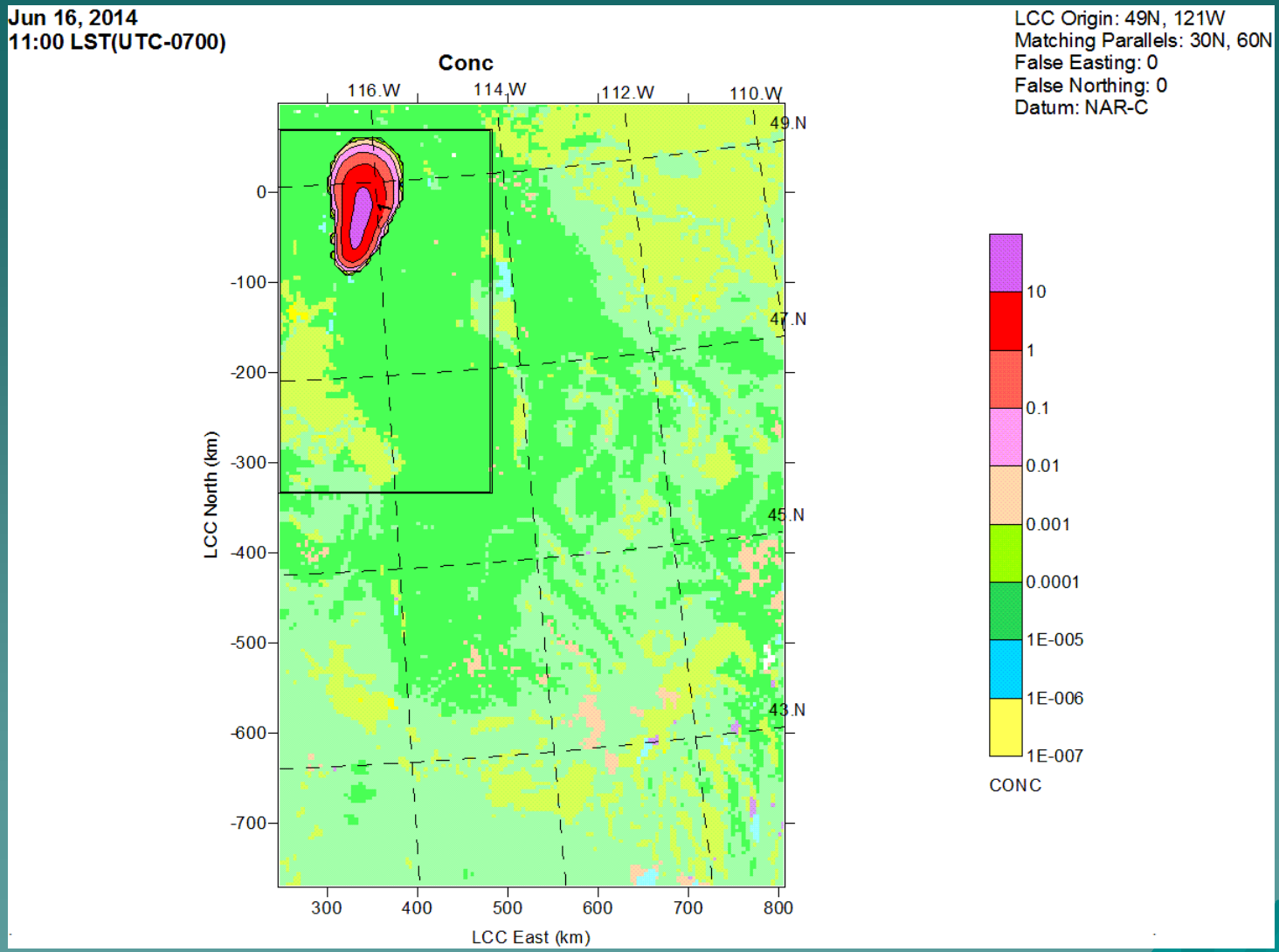
CONC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Matching Parallels: 30N, 60N
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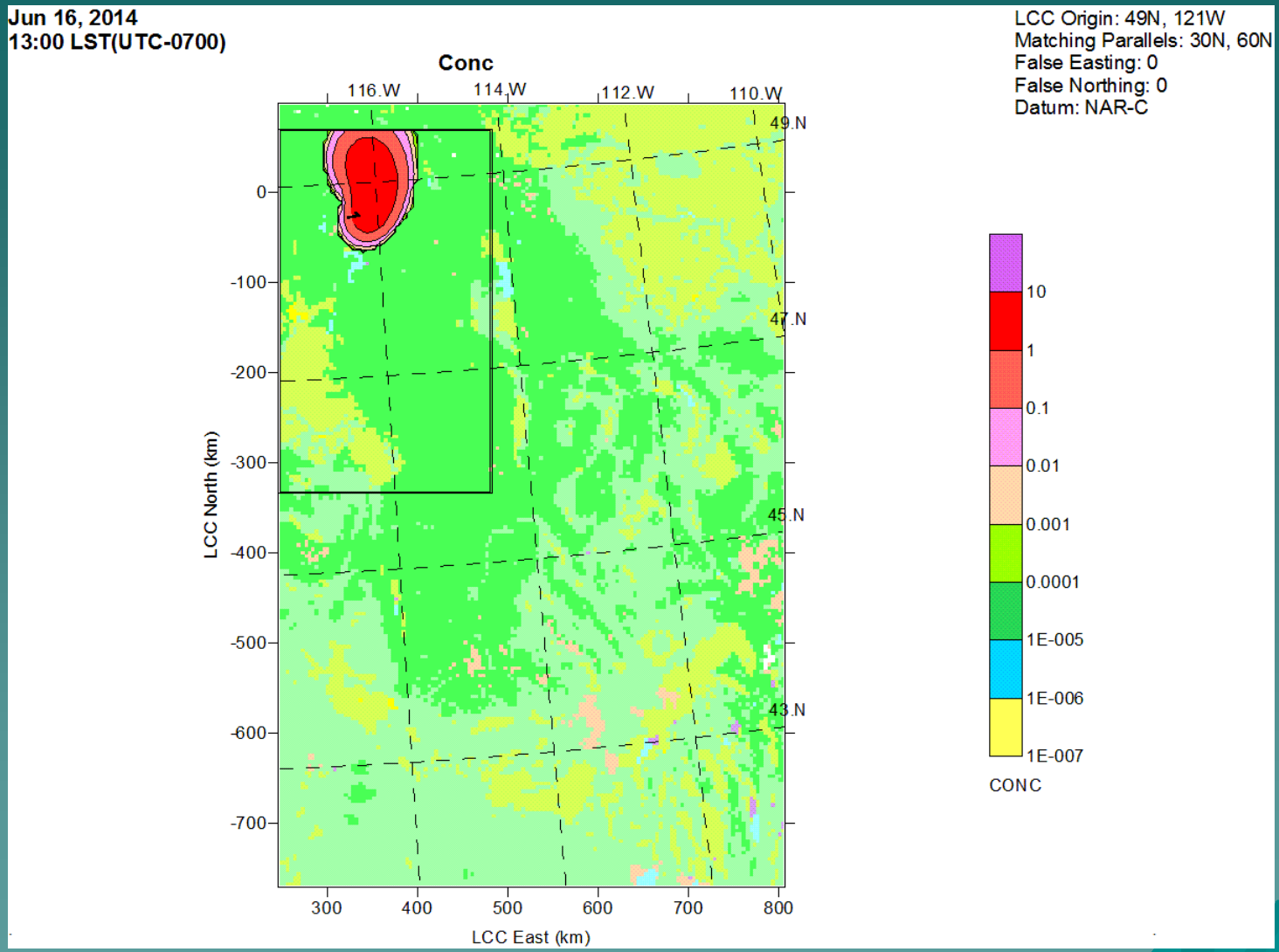
False Northing: 0
Datum: NAR-C
116.W
114.W
112.W
110.W
49.N
47.N
45.N
43.N
0
-100
-200
-300
-400
-500
-600
-700
LCC North (km)
300
400
500
600
700
800
LCC East (km)
10
1
0.1
0.01
0.001
0.0001
1E-005
1E-006
1E-007
CONC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Conc
LCC Origin: 49N, 121W
Matching Parallels: 30N, 60N
False Easting: 0
False Northing: 0
Datum: NAR-C
116.W
114.W
112.W
110.W
49.N
47.N
45.N
43.N
0
-100
-200
-300
-400
-500
-600
-700
LCC North (km)
300
400
500
600
700
800
LCC East (km)
10
1
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1E-006
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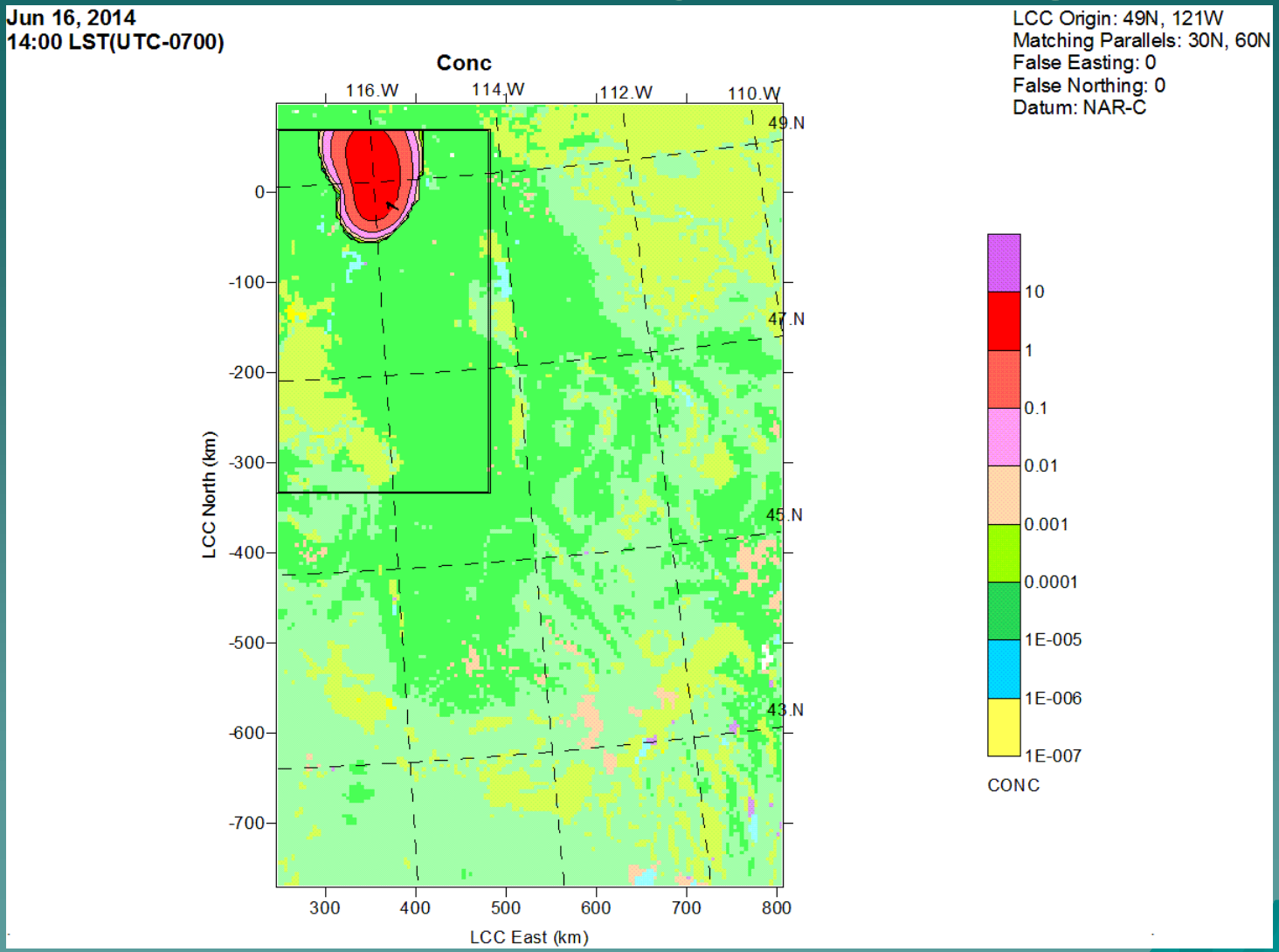
CONC

Preliminary Testing



Future Work

- Let modelers in Washington and Oregon know that we have the capability to model spills (pool fire plumes and river spill time of travel) throughout the NW (the purpose of this presentation).
- IF we are in the office, time to complete a model run can be 1 – 2 hours.
- But we caution that we are not funded to be on call or available 24/7.
- Continue to test the Crude oil pool fire scenarios.
- Upgrade the system, when time permits to utilize WRF met outputs directly through MMIF rather than or in addition to CALPUFF/CALMET.

Questions? Discussion?

Rick Hardy 208.373.0236

Wei Zhang 208.373.0338