

**APPENDIX L: COMPUTER MODEL STUDY 7:
Sound Absorbing Material Added to the Range
Sites 1 and 2 with Base and Alternate Range Orientations
Typical and Busy Day Scenarios
20 ft. tall berm**

Computer model study 7 was conducted with adding partitions under the roof to separate each shooting position and adding sound absorbent material to the underside of the ceiling and the partitions dividing the individual lanes. The models were run on Site 1: County Road Commission with the direction of fire to the north and to the north-northwest for the “busy day” scenario and Site 2: Sands West with the direction of fire to the north, northwest, and southwest with the “busy day” scenario.

1. The “busy day” scenario has 1 shooter on the 50 yard range, 200 yard range and on the 300 yard range firing a .223 rifle, one shooter on the 40 yard range firing a 12 gauge shotgun and 2 shooters on the 25 yard range firing 0.40 caliber handguns.
2. The “typical day” scenario has one shooter on the 300 yard range firing a .223 rifle; one shooter on the 40 yard range firing a 12 gauge shotgun and one shooter on the 25 yard range firing a 0.40 caliber handgun in the same one second time period.
3. The wind condition in the base model was modeled as downwind with 1 to 11 mph wind as the other in computer model studies 1 and 2.
4. The 50°F and 80% relative humidity condition was used in the models.
5. Sound absorbent material with an NRC greater than 1.00 was installed on the sides and ceiling of each lane.
6. The direction of fire was to the north and to the north-northwest for Site 1; and to the north, northwest and southwest for Site 2.
7. The berm height of 20 ft. was used in the reference model.
8. The sound levels shown on the noise contour maps are LAeq in dBA.

In Experiment 7, solid dividers are installed between each lane in the range at Site 1: County Road Commission oriented to the north and to the north-northwest and Site 2: Sands West range oriented to the north, northwest, and southwest with the 20 ft. tall downrange berm and the “busy day” scenario. A sound absorbent lining panel was added to the side walls and ceiling of each lane in the range building. This locates each shooter in a sound absorbent enclosure that reduces sound propagating out of the range building. The linear pressure score is reduced by approximately 89% for the Site 1: County Road Commission range oriented to the north-northwest and by approximately 90% for the Site 2: Sands West range oriented to the northwest.

The rough order of magnitude cost for installing solid dividers in each of the lanes and lining the ceiling and walls of each lane with a weather-resistant sound absorbing panel such as Troy Board manufactured by Troy Acoustics is \$85,300 and \$233,900 for raising the height of the berms to 20 ft. tall for a total incremental cost of \$319,200 over the base range.

Table L-1. Summary table of rating points for each scenario tested in Experiment 8.

BUSY DAY 6 SHOOTERS 20 FT BERM				
Site	DOF	LIN PRES	dB	PTS
SITE 1: MCRC	NNW	135	71	203
SITE 2: Sands	NW	253	74	635
SITE 2: Sands	N	333	75	711
SITE 1: MCRC	N	333	75	239
SITE 1: MCRC Reference	N	850	79	298
SITE 2: Sands	SW	1,033	80	698
SITE 2: Sands Reference	N	2,415	84	1149
TYPICAL DAY 3 SHOOTERS 20 FT BERM				
Site	DOF	LIN PRES	dB	PTS
SITE 1: MCRC	NNW	109	70	250
SITE 2: Sands	NW	117	71	680
SITE 2: Sands	SW	140	71	657
SITE 2: Sands	N	174	72	802
SITE 1: MCRC	N	230	74	263
SITE 1: MCRC Reference	N	359	76	354
SITE 2: Sands Reference	N	989	80	992



MARQUETTE CRC

MODEL L-1

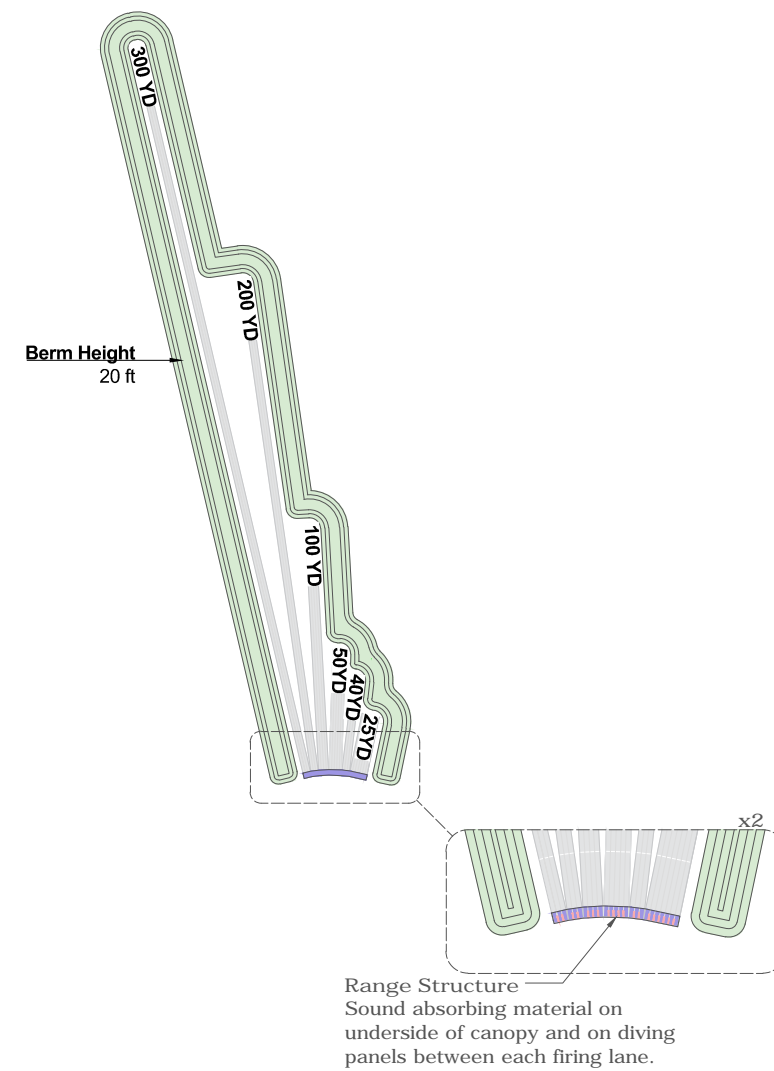
20 ft. Tall Side Berms
 Sound absorbing canopy and dividers

Typical Day:
 Shooters within 1 second:
 1 Rifle
 1 Shotgun
 1 Handgun

D.O.F. N

Wind: 1 to 11 mph downward

50°F and 80% R.H.





MARQUETTE CRC
MODEL L-2

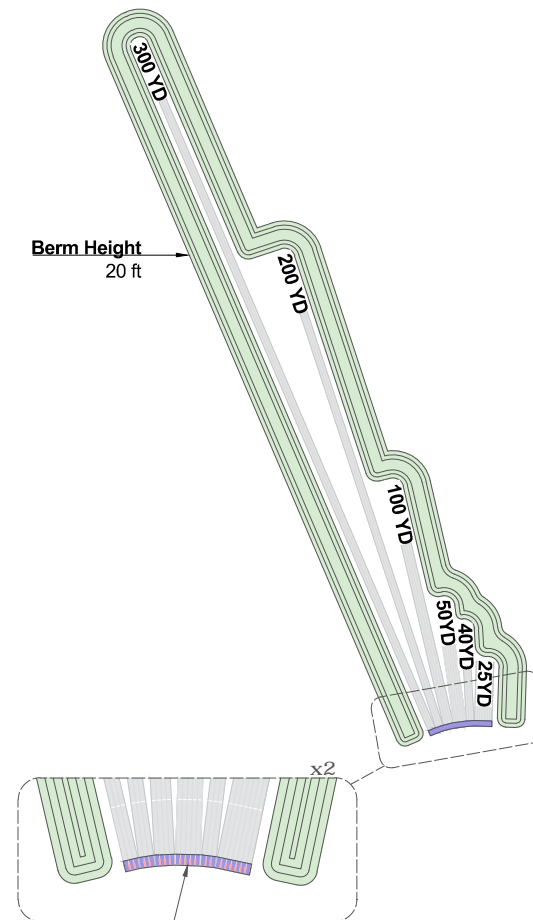
20 ft. Tall Side Berms
 Sound absorbing canopy and dividers

Typical Day:
 Shooters within 1 second:
 1 Rifle
 1 Shotgun
 1 Handgun

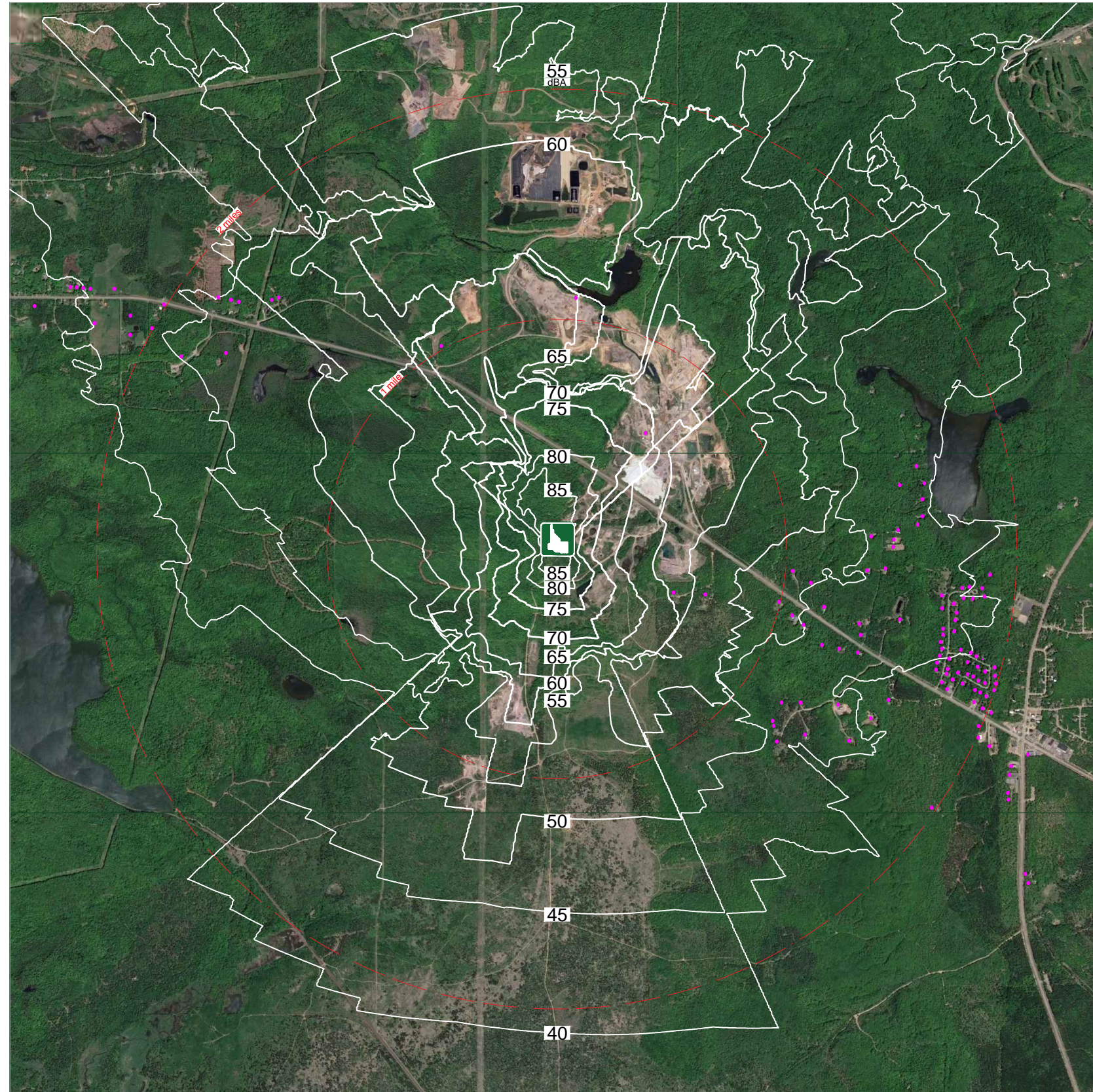
D.O.F. NNW

Wind: 1 to 11 mph downward

50°F and 80% R.H.



Range Structure
 Sound absorbing material on
 underside of canopy and on diving
 panels between each firing lane.



MARQUETTE CRC
MODEL L-3

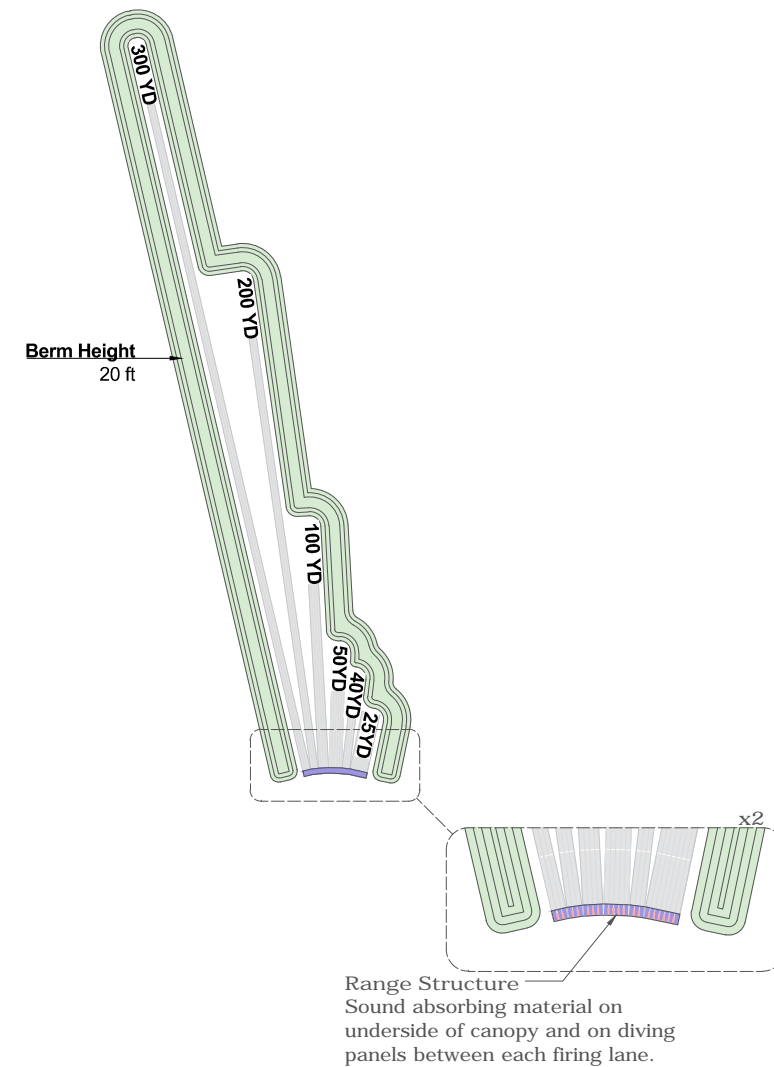
20 ft. Tall Side Berms
 Sound absorbing canopy and dividers

Busy Day:
 Shooters within 1 second:
 3 Rifles
 1 Shotgun
 2 Handguns

D.O.F. N

Wind: 1 to 11 mph downward

50°F and 80% R.H.





MARQUETTE CRC
MODEL L-4

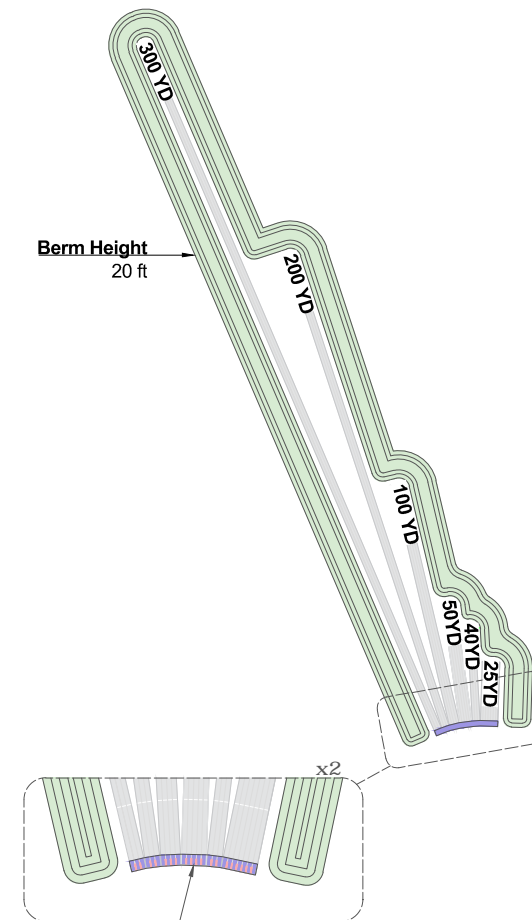
20 ft. Tall Side Berms
 Sound absorbing canopy and dividers

Busy Day:
 Shooters within 1 second:
 3 Rifles
 1 Shotgun
 2 Handguns

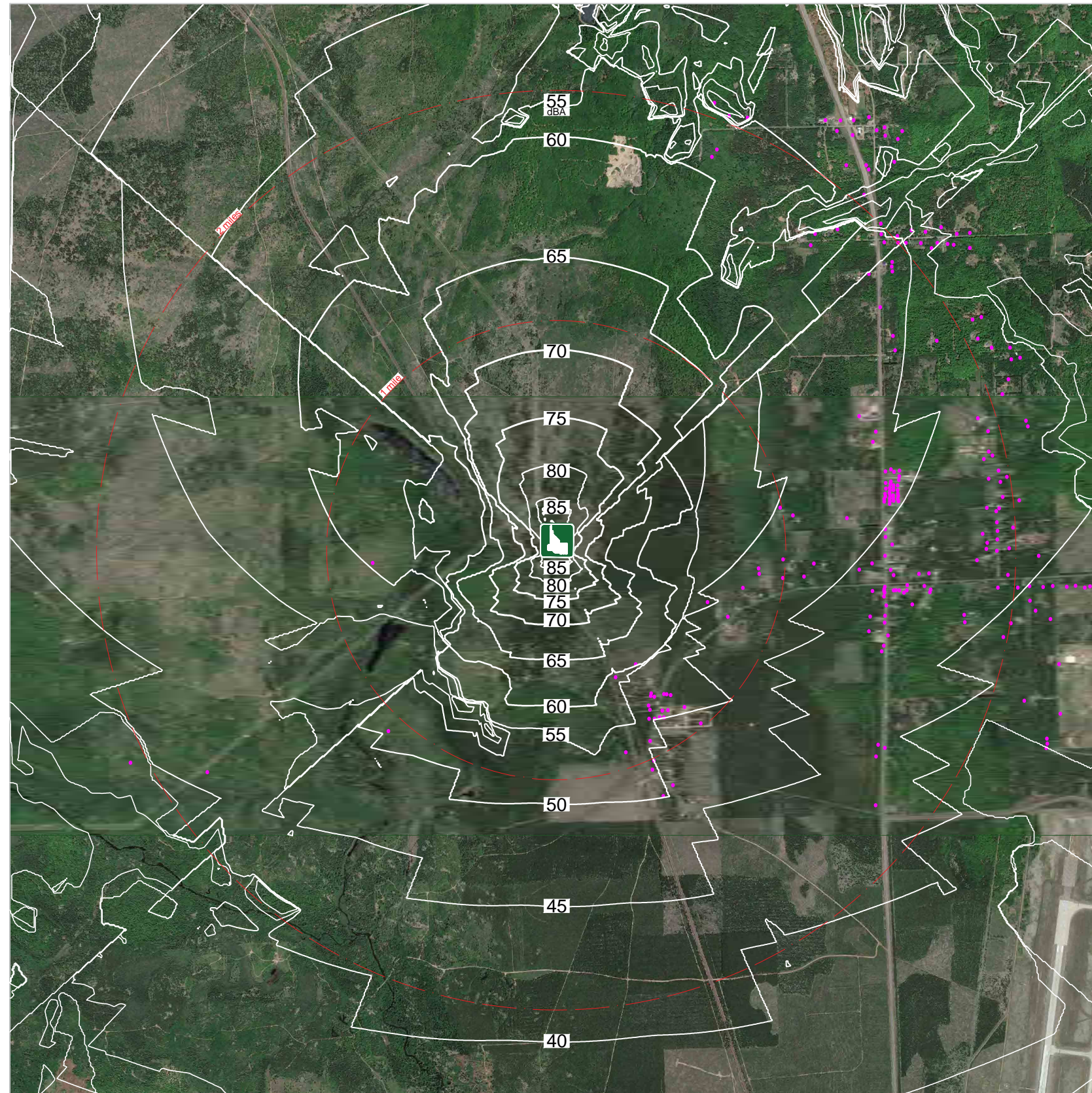
D.O.F. NNW

Wind: 1 to 11 mph downward

50°F and 80% R.H.



Range Structure
 Sound absorbing material on
 underside of canopy and on diving
 panels between each firing lane.



SANDS
MODEL L-5

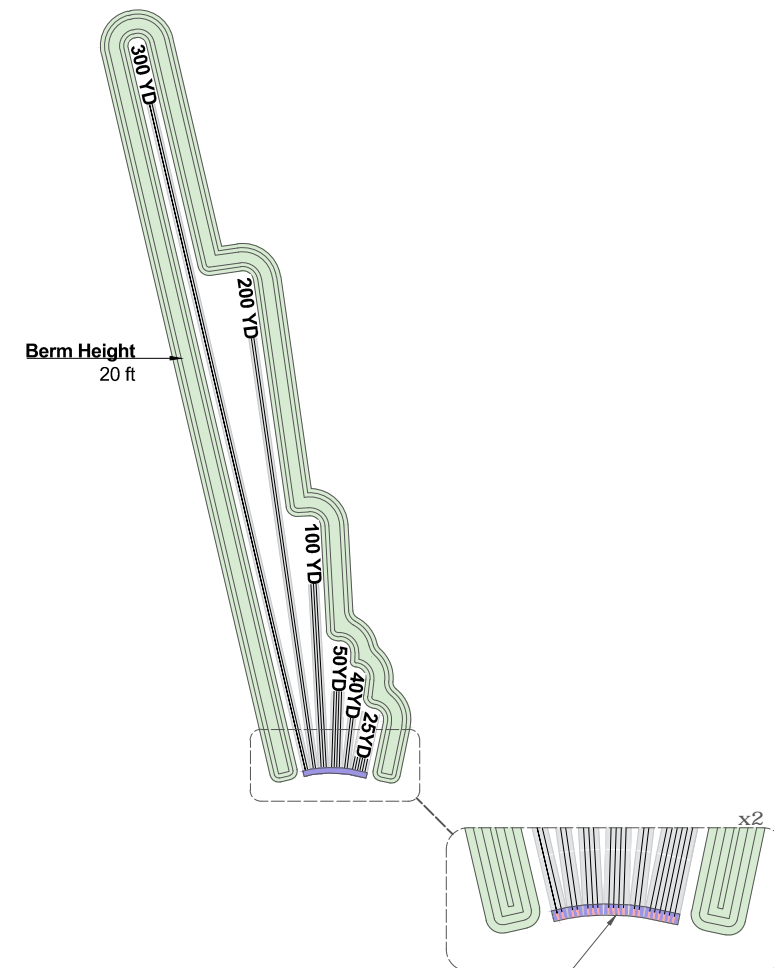
20 ft. Tall Side Berms
 Sound absorbing canopy and dividers

Typical Day:
 Shooters within 1 second:
 1 Rifle
 1 Shotgun
 1 Handgun

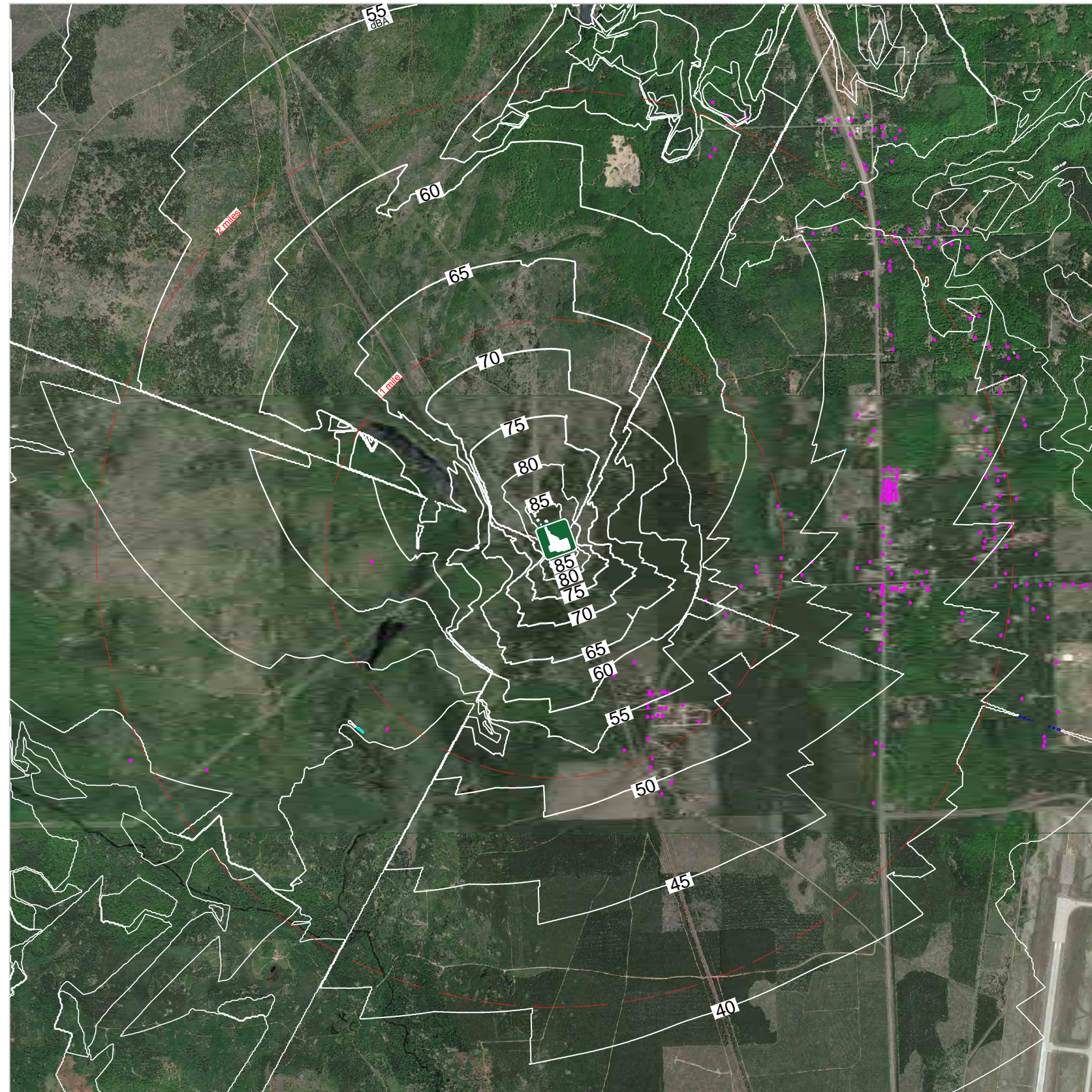
D.O.F. N

Wind: 1 to 11 mph downward

50°F and 80% R.H.



Range Structure
 Sound absorbing material on
 underside of canopy and on diving
 panels between each firing lane.



SANDS
MODEL L-6

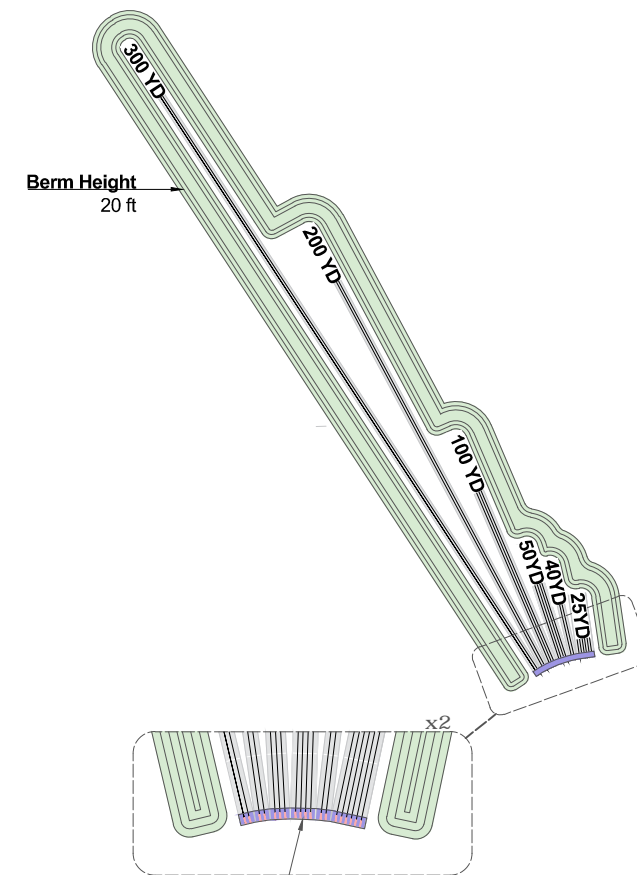
20 ft. Tall Side Berms
 Sound absorbing canopy and dividers

Typical Day:
 Shooters within 1 second:
 1 Rifle
 1 Shotgun
 1 Handgun

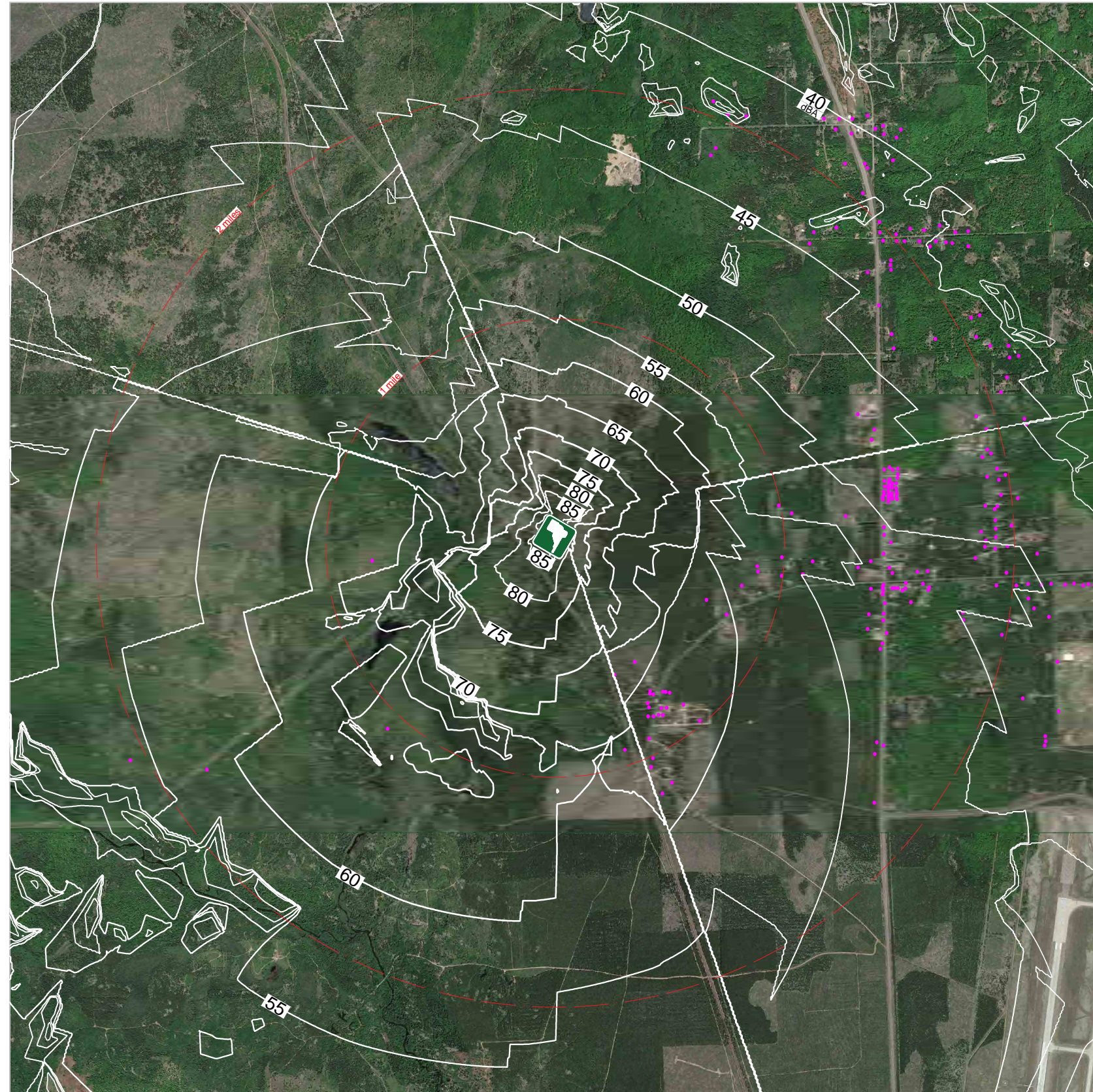
D.O.F. NW

Wind: 1 to 11 mph downward

50°F and 80% R.H.



Range Structure
 Sound absorbing material on
 underside of canopy and on diving
 panels between each firing lane.



SANDS
MODEL L-7

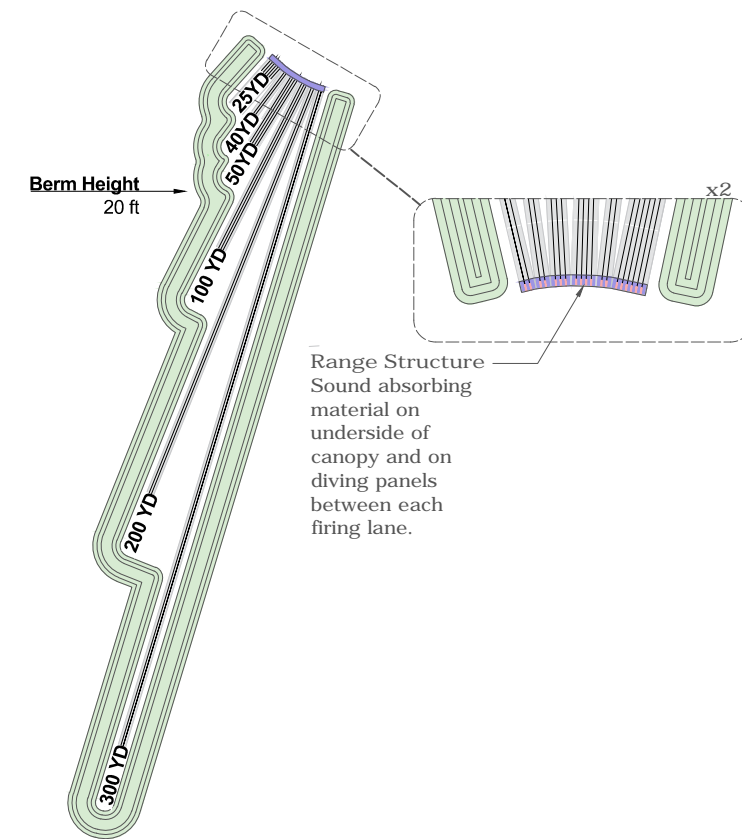
20 ft. Tall Side Berms
 Sound absorbing canopy and dividers

Typical Day:
 Shooters within 1 second:
 1 Rifle
 1 Shotgun
 1 Handgun

D.O.F. SW

Wind: 1 to 11 mph downward

50°F and 80% R.H.





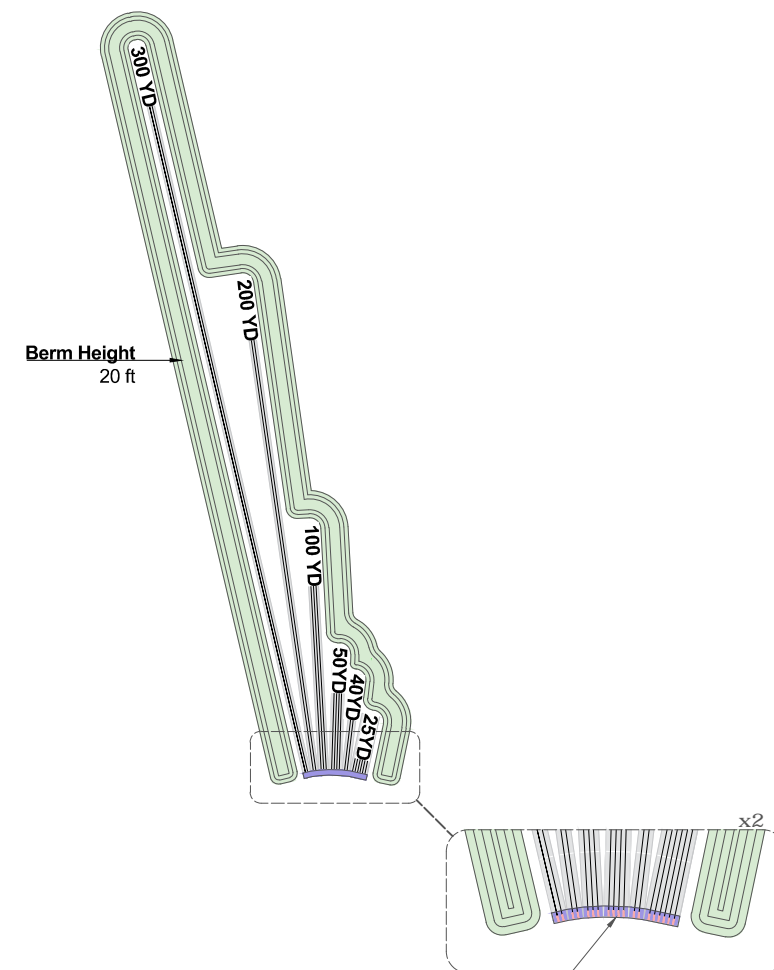
SANDS
MODEL L-8

20 ft. Tall Side Berms
 Sound absorbing canopy and dividers

Busy Day:
 Shooters within 1 second:
 3 Rifles
 1 Shotgun
 2 Handguns

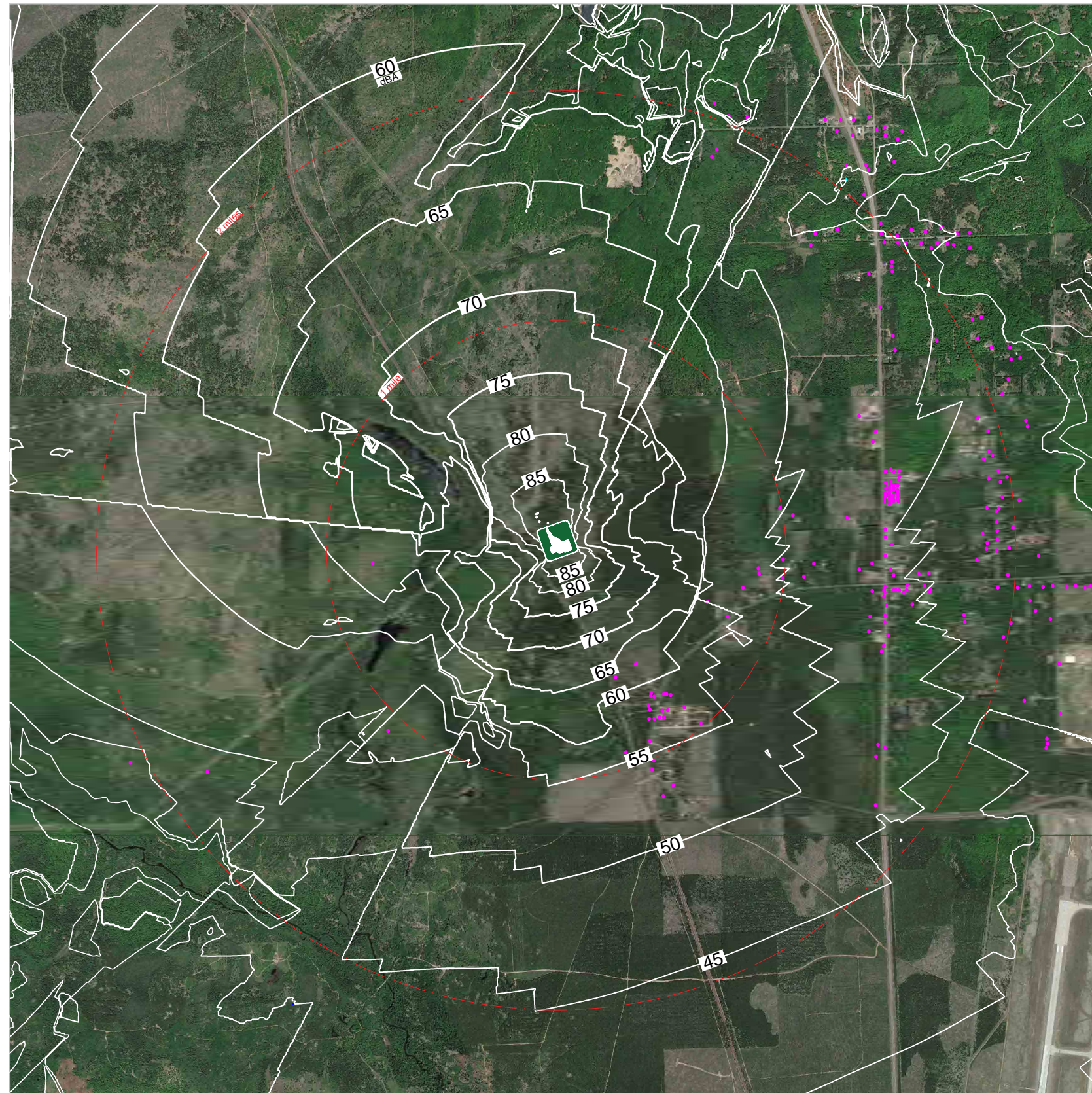
D.O.F. N

Wind: 1 to 11 mph downward
 50°F and 80% R.H.



Berm Height
 20 ft

Range Structure
 Sound absorbing material on
 underside of canopy and on diving
 panels between each firing lane.



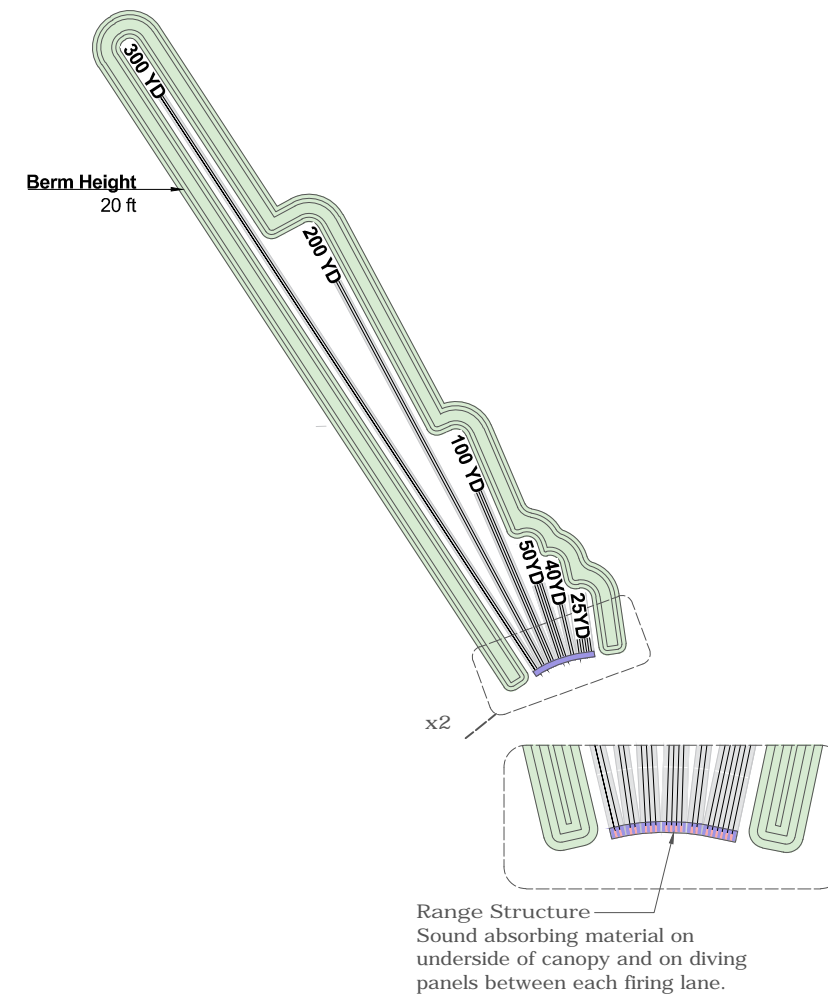
SANDS
MODEL L-9

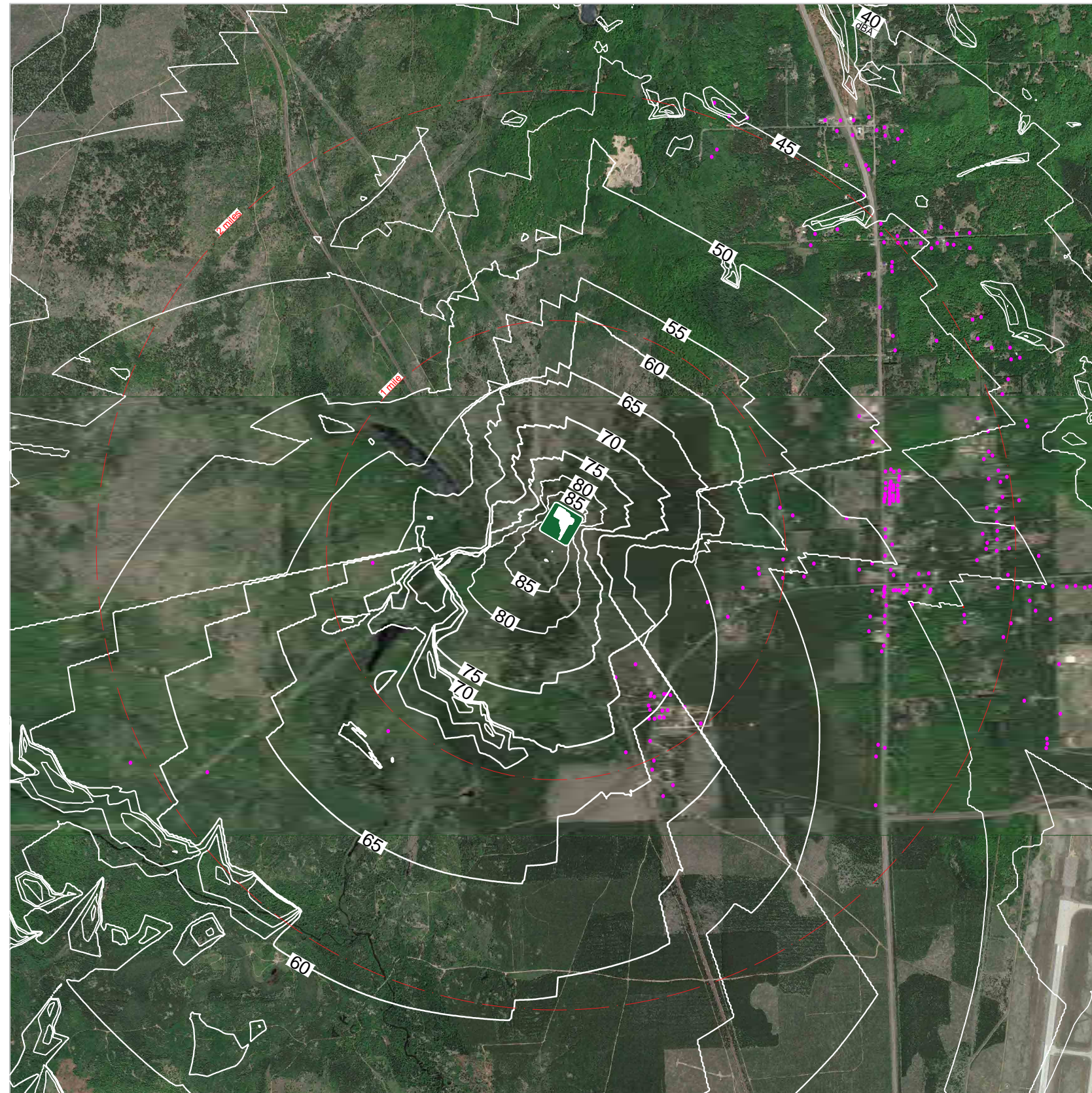
20 ft. Tall Side Berms
 Sound absorbing canopy and dividers

Busy Day:
 Shooters within 1 second:
 3 Rifles
 1 Shotgun
 2 Handguns

D.O.F. NW

Wind: 1 to 11 mph downward
 50°F and 80% R.H.





SANDS
MODEL L-10

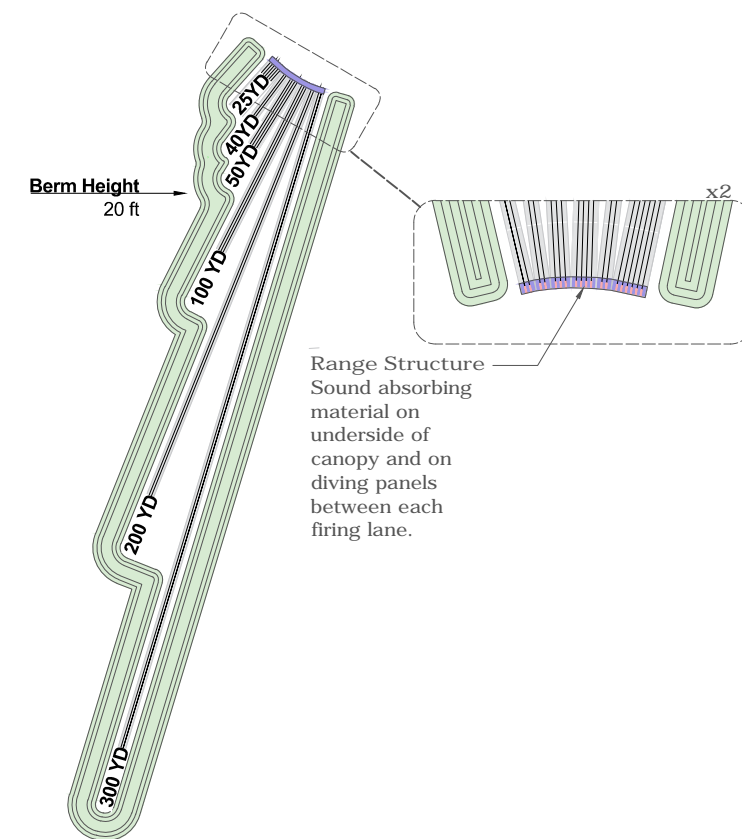
20 ft. Tall Side Berms
 Sound absorbing canopy and dividers

Busy Day:
 Shooters within 1 second:
 3 Rifles
 1 Shotgun
 2 Handguns

D.O.F. SW

Wind: 1 to 11 mph downward

50°F and 80% R.H.



**APPENDIX M: COMPUTER MODEL STUDY 8:
Side and Rear Walls Added to the Range Structure
Sites 1 and 2 with the Base and Alternate Range Orientations
Typical and Busy Day Scenarios
20 ft. tall berm**

Computer model study 8 was conducted with side and rear walls added to the range structure so the firing positions were open only in the direction of fire. A sound absorbent material was added to the inside face of the side and rear walls as well as to the partitions dividing the individual lanes and ceiling described in Computer Model Study 7. The models were run on Site 1: County Road Commission with the direction of fire to the north and to the north-northwest for the “busy day” scenario and Site 2: Sands West with the direction of fire to the north, northwest, and southwest with the “busy day” scenario.

1. The “busy day” scenario has 1 shooter on the 50 yard range, 200 yard range and on the 300 yard range firing a .223 rifle, one shooter on the 40 yard range firing a 12 gauge shotgun and 2 shooters on the 25 yard range firing 0.40 caliber handguns.
2. The “typical day” scenario has one shooter on the 300 yard range firing a .223 rifle; one shooter on the 40 yard range firing a 12 gauge shotgun and one shooter on the 25 yard range firing a 0.40 caliber handgun in the same one second time period.
3. The wind condition in the base model was modeled as downwind with 1 to 11 mph wind as the other in computer model studies 1 and 2.
4. The 50°F and 80% relative humidity condition was used in the models.
5. Side walls and a rear wall were added to the range structure so the range was only open in the direction of fire. Wood frame walls were built between each firing lane with plywood covering. A sound absorbent panel was installed on the sides and ceiling of each lane as well as on the side and rear walls of the entire range structure.
6. The direction of fire was to the north and to the north-northwest for Site 1; and to the north, northwest and southwest for Site 2.
7. The berm height of 20 ft. was used in the reference model.
8. The sound levels shown on the noise contour maps are LA eq in dBA.

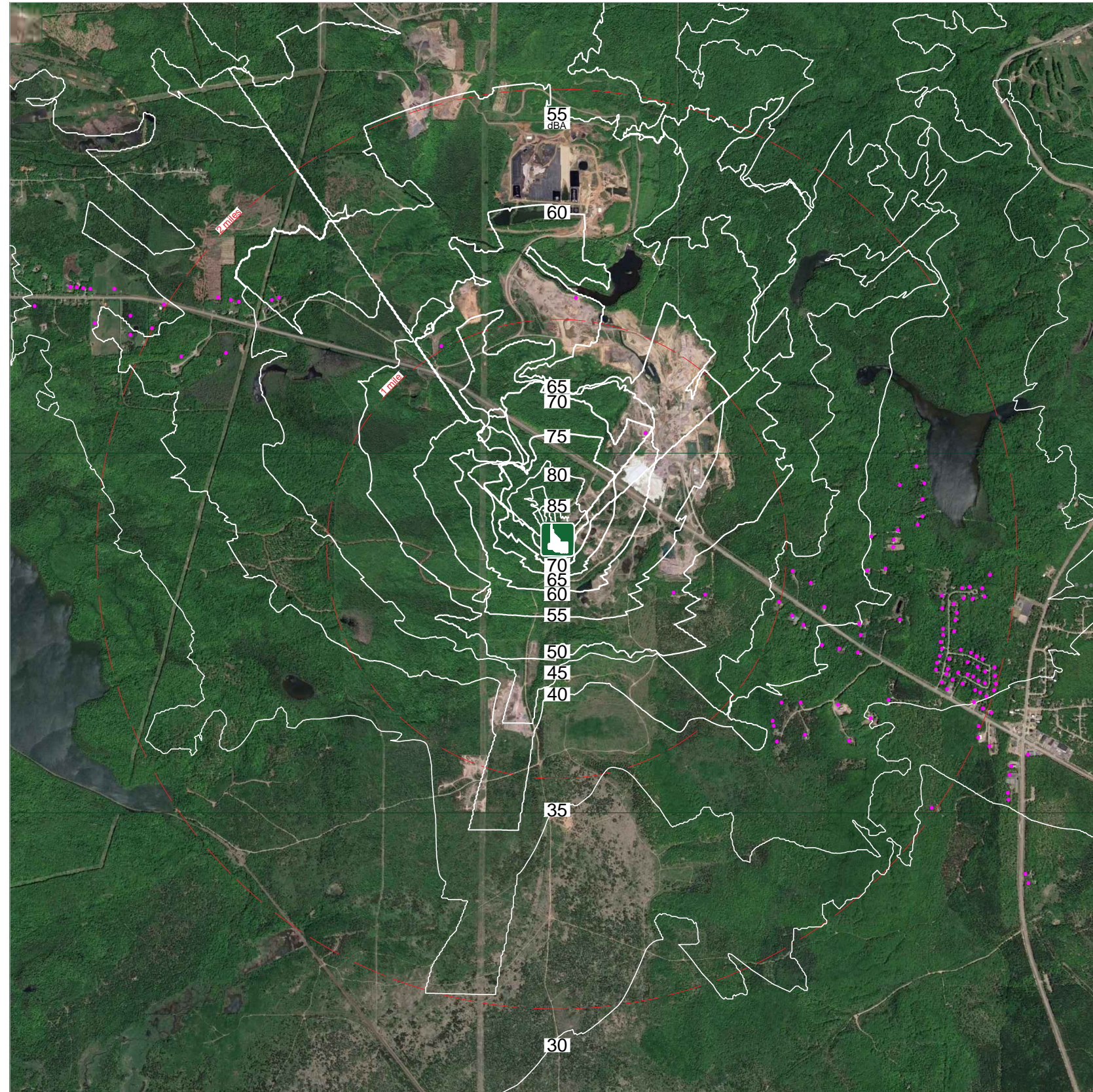
In Experiment 8, solid side walls and a rear wall were added to the range building in addition to the solid dividers installed between each lane in the Site 1: County Road Commission range oriented to the north and to the north-northwest and Site 2: Sands West range oriented to the north, northwest and southwest with the 20 ft. tall downrange berm and the “busy day” scenario in Experiment 7. A sound absorbent lining panel is added to the rear wall, side walls, interior lane dividing walls and the ceiling of each lane in the range building. This locates each shooter in a sound absorbent enclosure on 3 sides that reduces sound propagating out of the range building.

The linear pressure score is reduced by approximately 95% for the Site 2: Sands West range oriented to the northwest and by approximately 90% for the Site 1: County Road Commission range oriented to the north-northwest. The rough order of magnitude cost for installing the side walls, rear wall, solid dividers in each of the lanes and lining the ceiling and walls of each lane with a weather-resistant sound absorbing panel such as Troy Board manufactured by Troy Acoustics is \$133,500 and \$233,900 for raising the height of the berm to 20 feet tall for a total increase in cost of \$367,400 over the base range.

It is worthwhile to note that Site 2: Sands West with the range oriented to the northwest has the lowest linear pressure score with the mitigation scheme.

Table M-1. Summary table of rating points for each scenario tested in Experiment 8.

BUSY DAY 6 SHOOTERS 20 FT BERM				
Site	DOF	LIN PRES	dB	PTS
SITE 2: Sands	NW	114	71	804
SITE 1: MCRC	NNW	124	71	307
SITE 2: Sands	N	251	74	683
SITE 1: MCRC	N	314	75	329
SITE 1: MCRC Reference	N	850	79	298
SITE 2: Sands	SW	963	80	744
SITE 2: Sands Reference	N	2,415	84	1149
TYPICAL DAY 3 SHOOTERS 20 FT BERM				
Site	DOF	LIN PRES	dB	PTS
SITE 2: Sands	NW	56	67	641
SITE 1: MCRC	NNW	92	70	243
SITE 2: Sands	N	125	71	770
SITE 2: Sands	SW	132	71	555
SITE 1: MCRC	N	226	74	260
SITE 1: MCRC Reference	N	359	76	354
SITE 2: Sands Reference	N	989	80	992



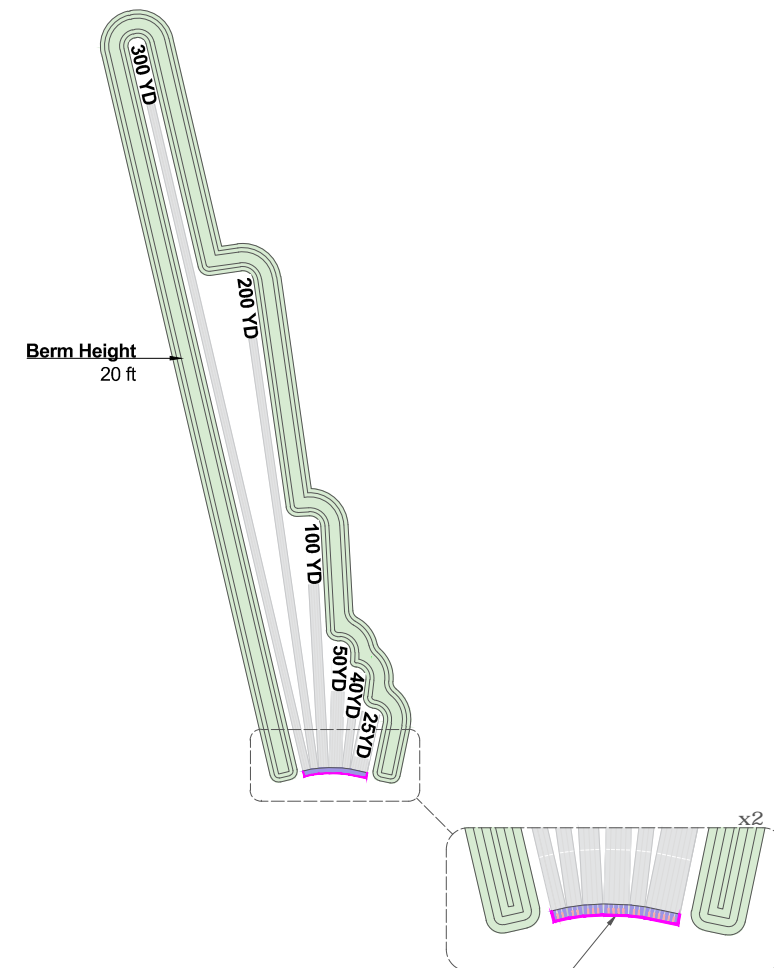
MARQUETTE CRC
MODEL M-1

20 ft. Tall Side Berms
 Sound absorbing canopy and dividers
 Structure with rear and side walls

Typical Day:
 Shooters within 1 second:
 1 Rifle
 1 Shotgun
 1 Handgun

D.O.F. N

Wind: 1 to 11 mph downward
 50°F and 80% R.H.



Range Structure
 Sound absorbing material on underside of canopy and on diving panels between each firing lane.
 Rear and side walls added to the structure so the firing positions are opened only in D.O.F.



MARQUETTE CRC
MODEL M-2

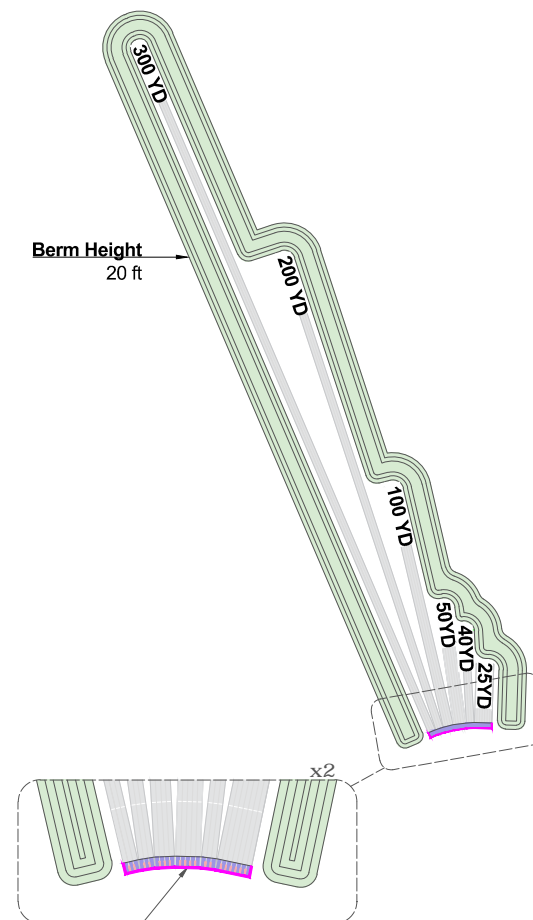
20 ft. Tall Side Berms
 Sound absorbing canopy and dividers
 Structure with rear and side walls

Typical Day:
 Shooters within 1 second:
 1 Rifle
 1 Shotgun
 1 Handgun

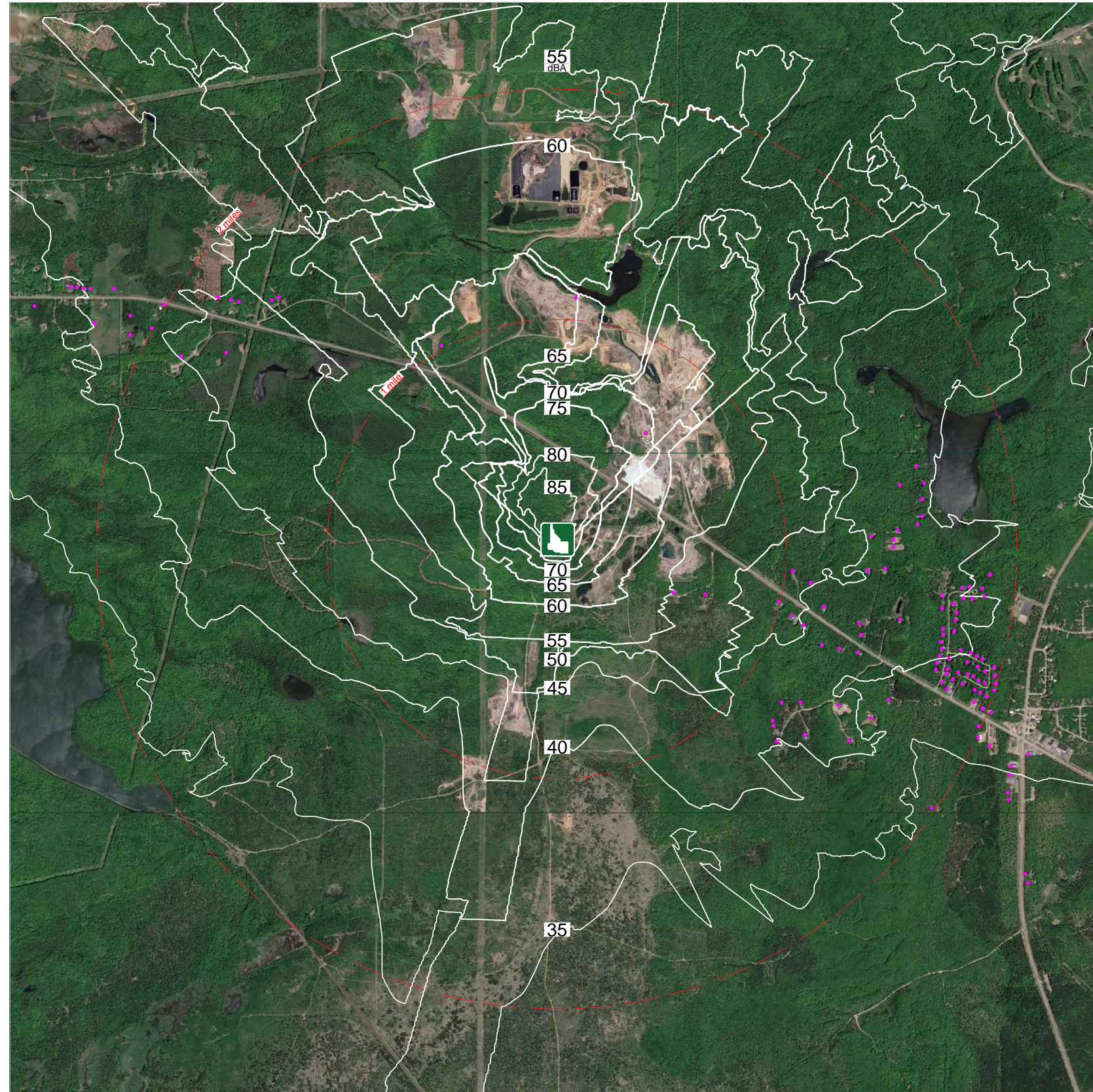
D.O.F. NNW

Wind: 1 to 11 mph downward

50°F and 80% R.H.



Range Structure
 Sound absorbing material on underside of canopy and on diving panels between each firing lane.
 Rear and side walls added to the structure so the firing positions are opened only in D.O.F.



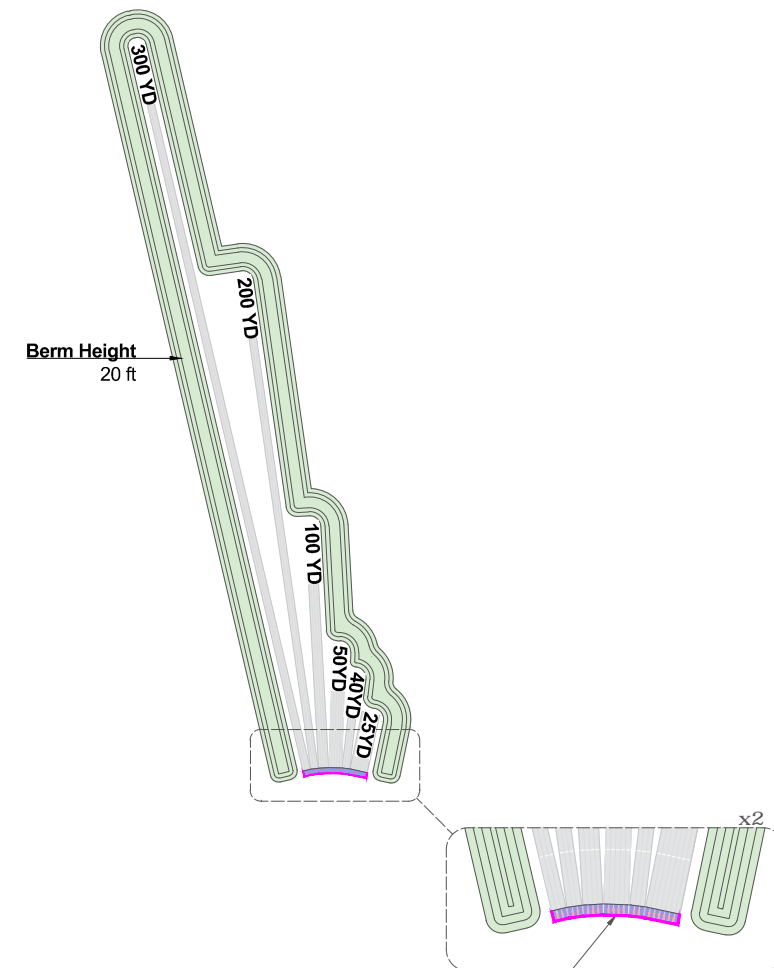
MARQUETTE CRC
MODEL M-3

20 ft. Tall Side Berms
 Sound absorbing canopy and dividers
 Structure with rear and side walls

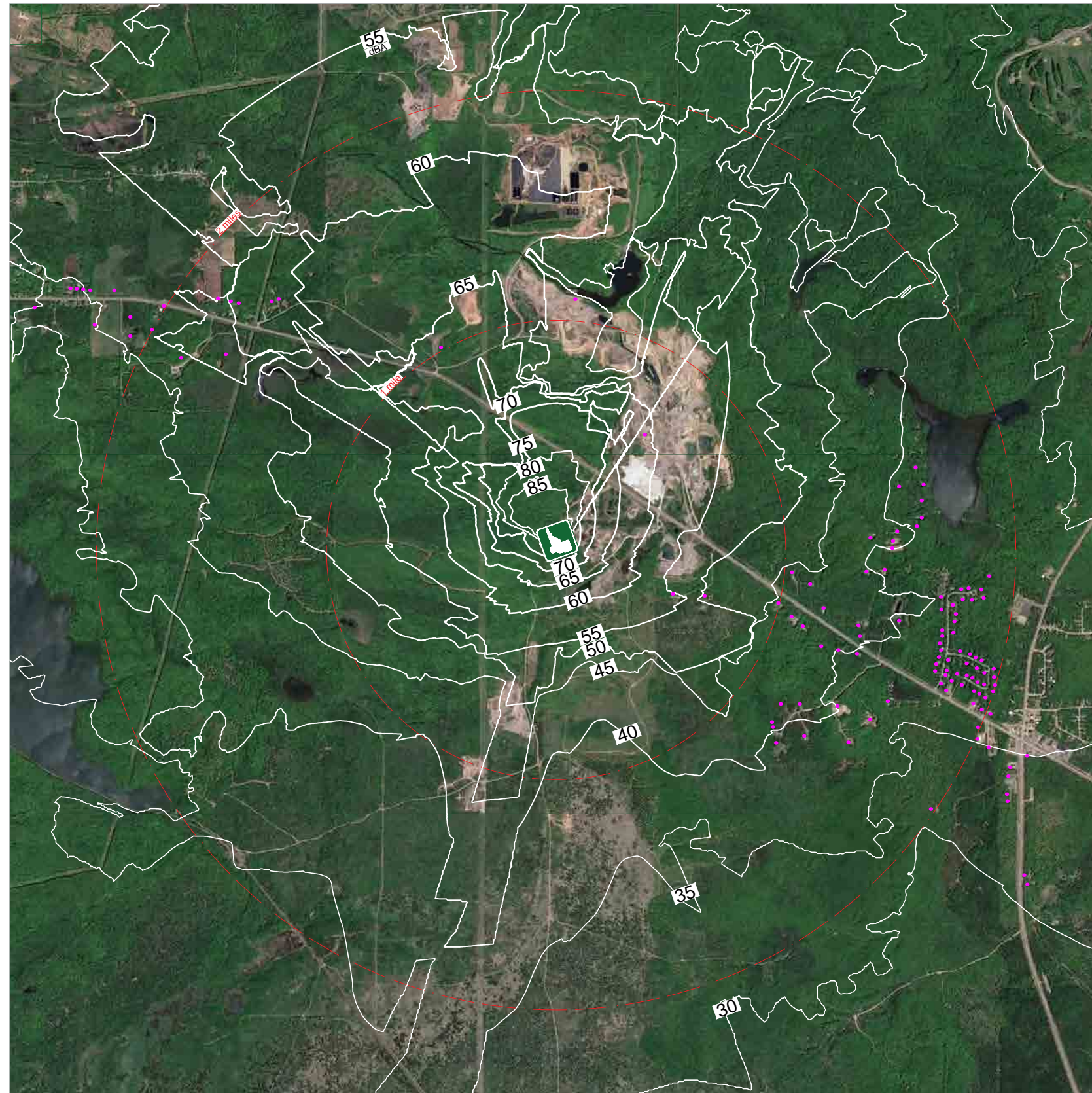
Busy Day:
 Shooters within 1 second:
 3 Rifles
 1 Shotgun
 2 Handguns

D.O.F. N

Wind: 1 to 11 mph downward
 50°F and 80% R.H.



Range Structure
 Sound absorbing material on underside of canopy and on diving panels between each firing lane.
 Rear and side walls added to the structure so the firing positions are opened only in D.O.F.



MARQUETTE CRC
MODEL M-4

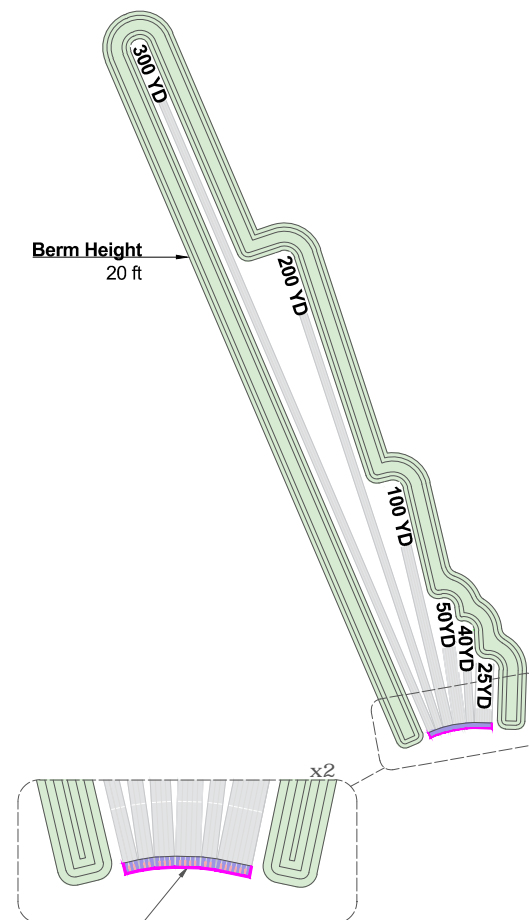
20 ft. Tall Side Berms
 Sound absorbing canopy and dividers
 Structure with rear and side walls

Busy Day:
 Shooters within 1 second:
 3 Rifles
 1 Shotgun
 2 Handguns

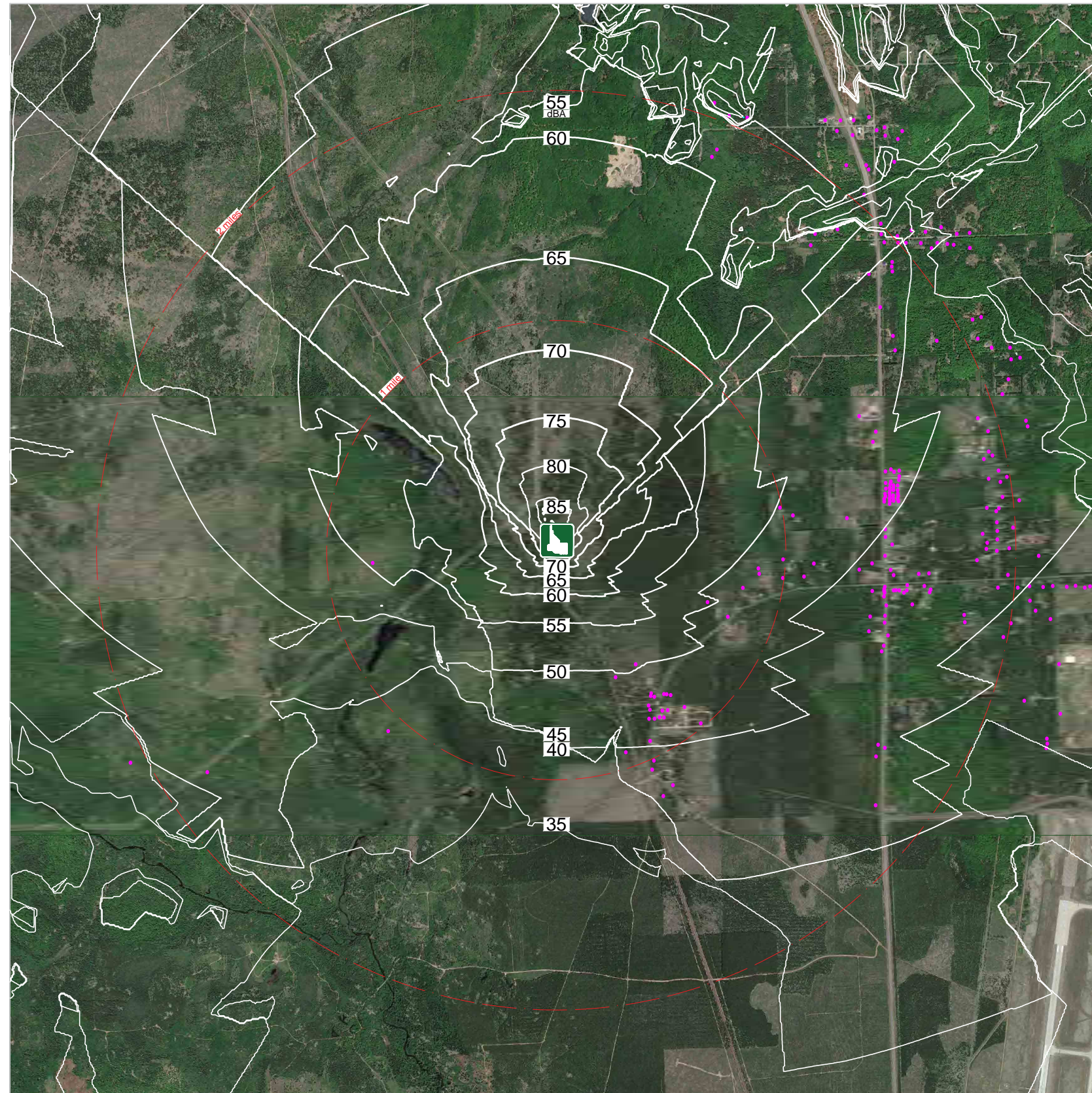
D.O.F. NNW

Wind: 1 to 11 mph downward

50°F and 80% R.H.



Range Structure
 Sound absorbing material on underside of canopy and on diving panels between each firing lane.
 Rear and side walls added to the structure so the firing positions are opened only in D.O.F.



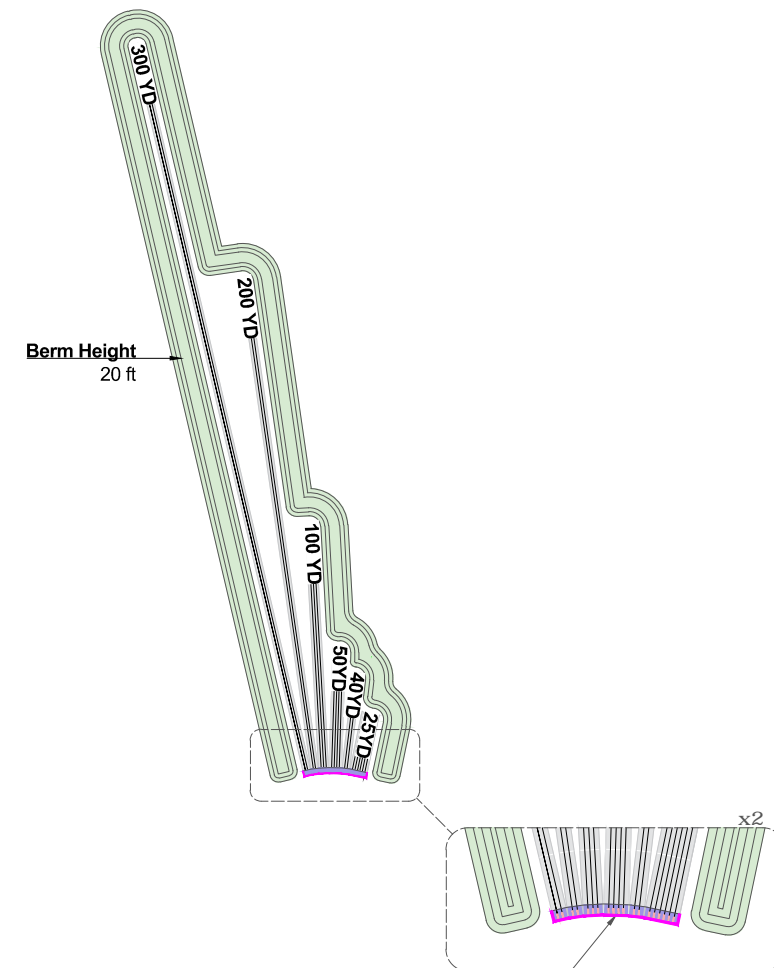
SANDS
MODEL M-5

20 ft. Tall Side Berms
 Sound absorbing canopy and dividers
 Structure with rear and side walls

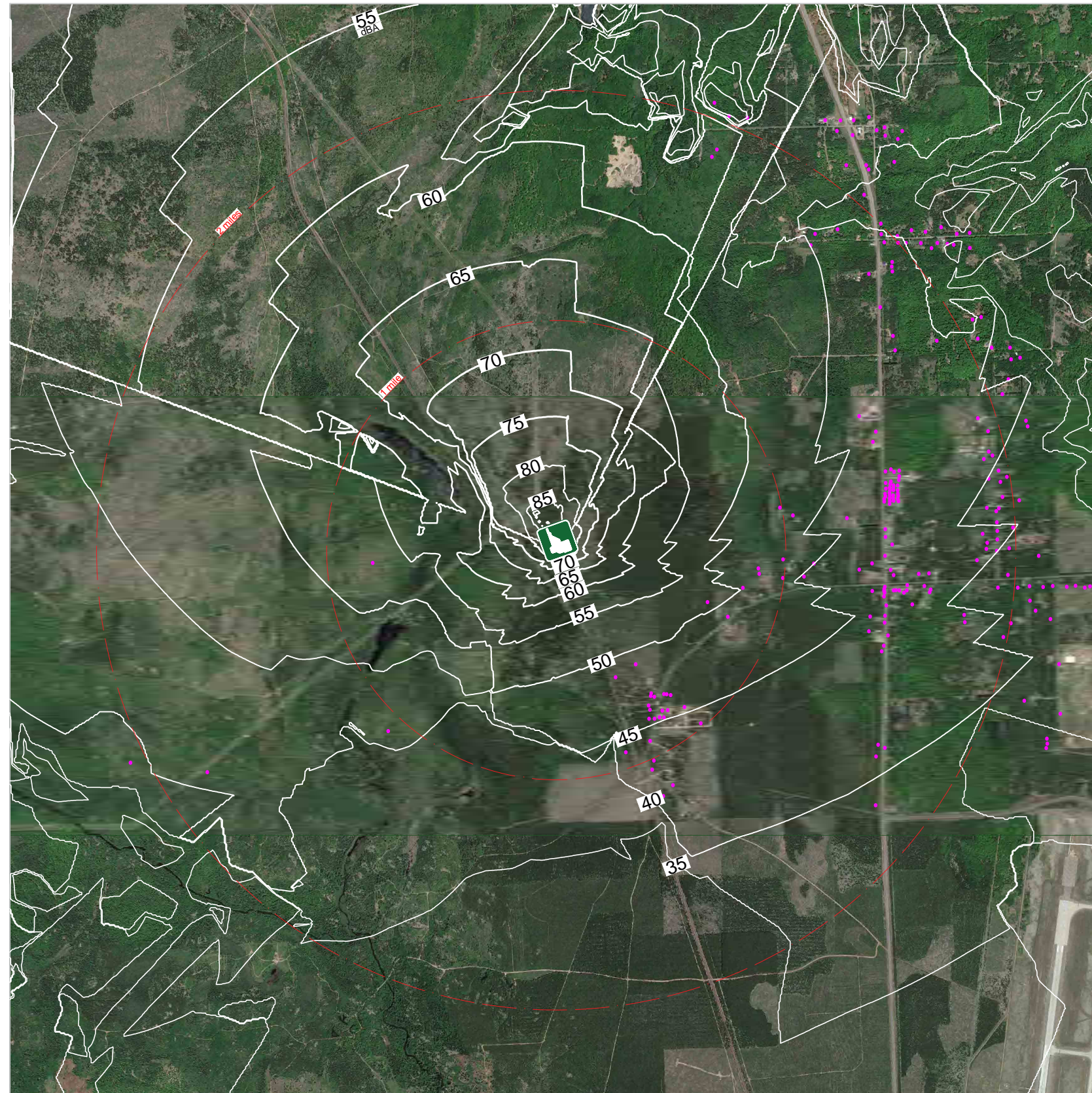
Typical Day:
 Shooters within 1 second:
 1 Rifle
 1 Shotgun
 1 Handgun

D.O.F. N

Wind: 1 to 11 mph downward
 50°F and 80% R.H.



Range Structure
 Sound absorbing material on underside of canopy and on dividing panels between each firing lane.
 Rear and side walls added to the structure so the firing positions are opened only in D.O.F.



SANDS
MODEL M-6

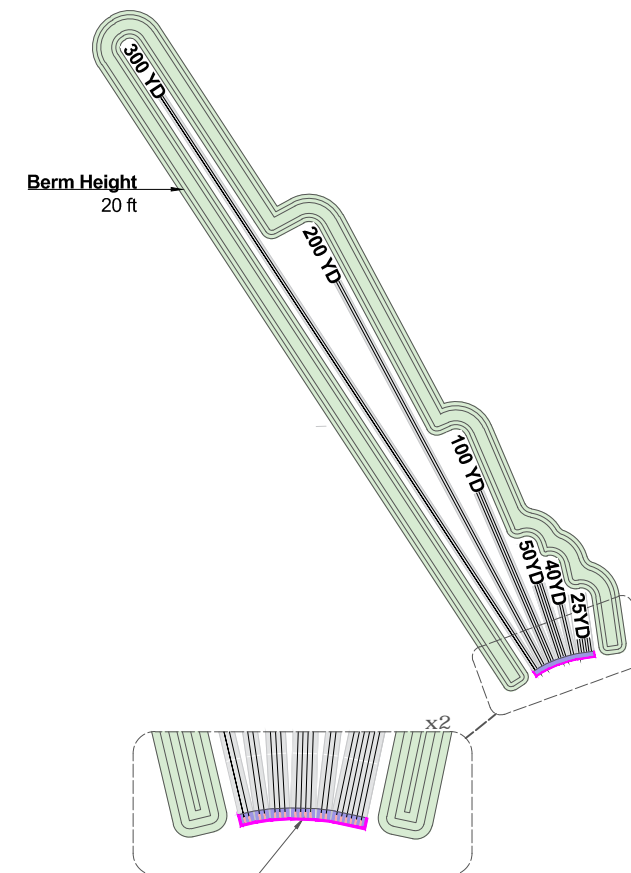
20 ft. Tall Side Berms
 Sound absorbing canopy and dividers
 Structure with rear and side walls

Typical Day:
 Shooters within 1 second:
 1 Rifle
 1 Shotgun
 1 Handgun

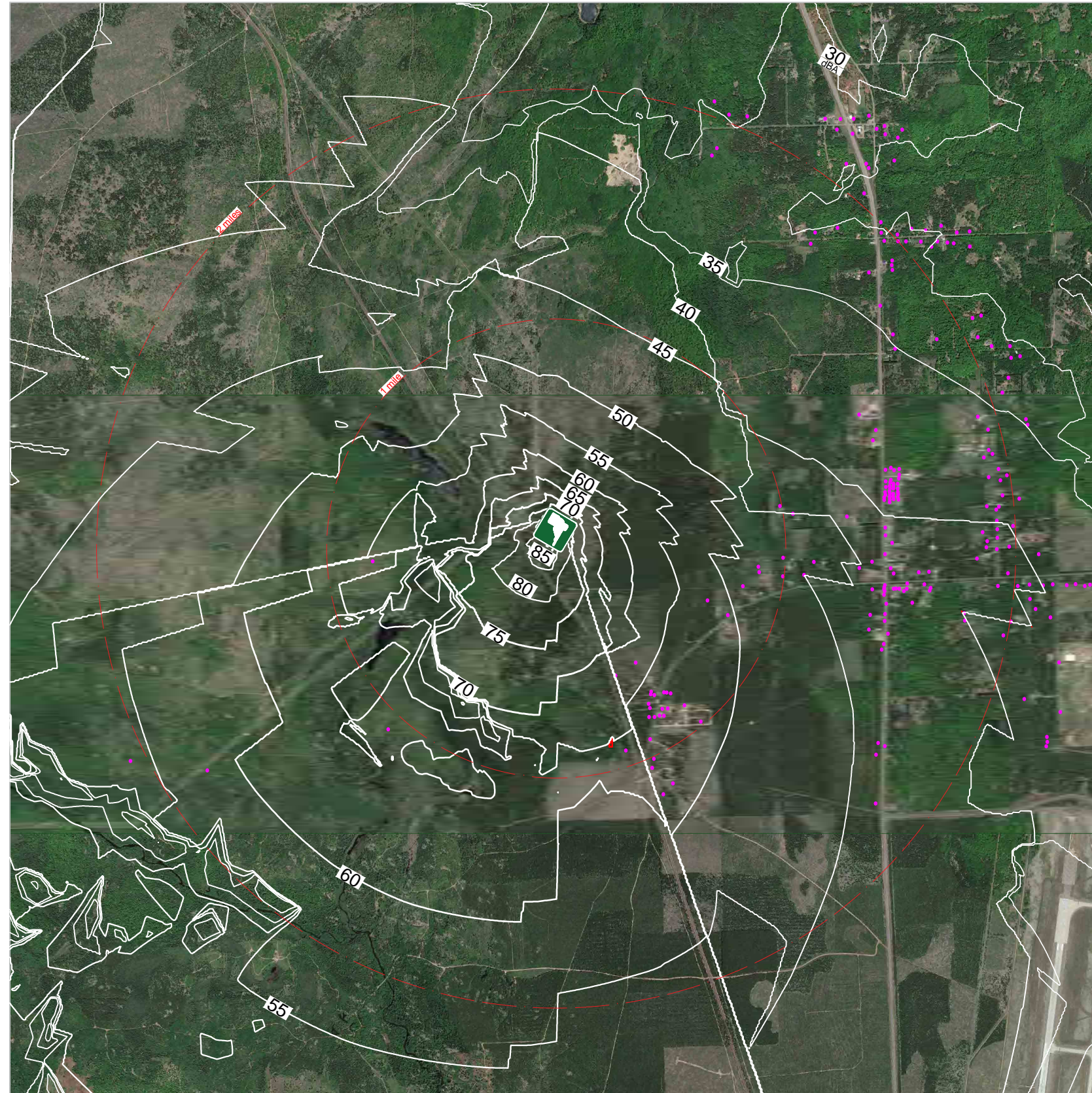
D.O.F. NW

Wind: 1 to 11 mph downward

50°F and 80% R.H.



Range Structure
 Sound absorbing material on underside of canopy and
 on dividing panels between each firing lane.
 Rear and side walls added to the structure so the firing
 positions are opened only in D.O.F.



SANDS
MODEL M-7

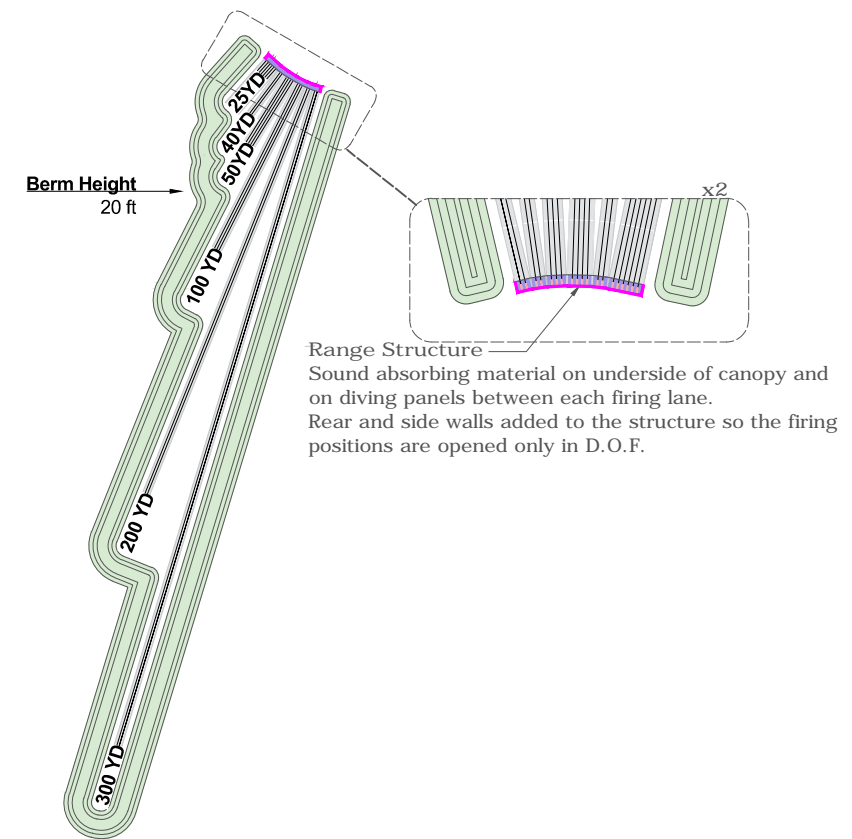
20 ft. Tall Side Berms
 Sound absorbing canopy and dividers
 Structure with rear and side walls

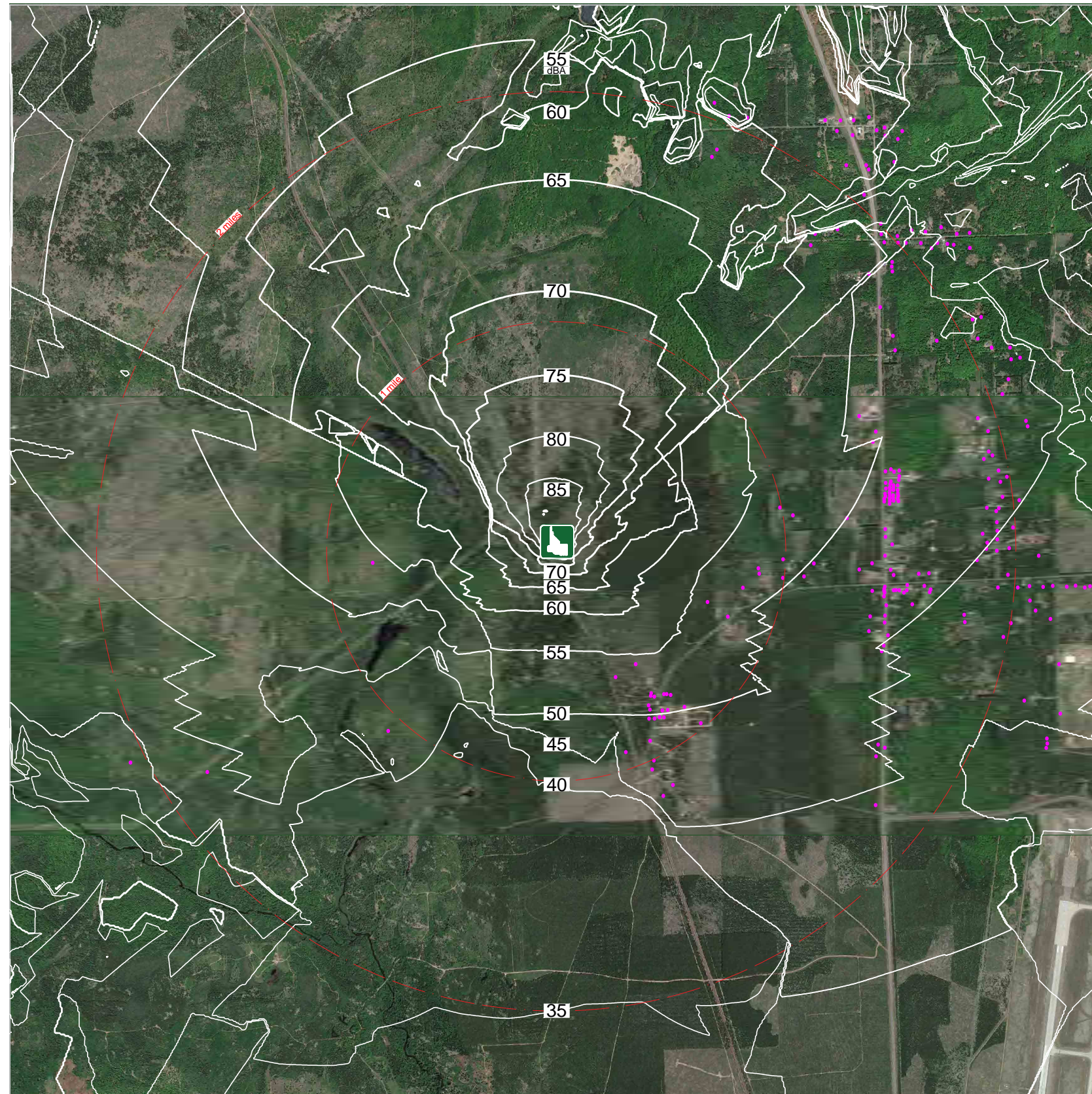
Typical Day:
 Shooters within 1 second:
 1 Rifle
 1 Shotgun
 1 Handgun

D.O.F. SW

Wind: 1 to 11 mph downward

50°F and 80% R.H.





**SANDS
 MODEL M-8**

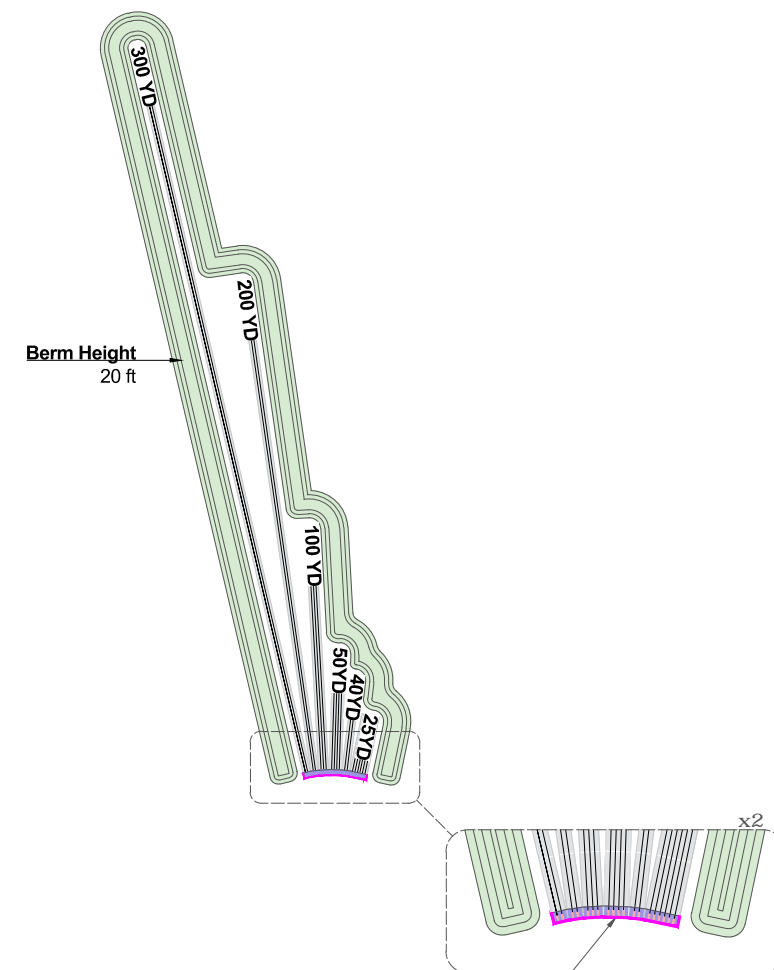
20 ft. Tall Side Berms
 Sound absorbing canopy and dividers
 Structure with rear and side walls

Busy Day:
 Shooters within 1 second:
 3 Rifles
 1 Shotgun
 2 Handguns

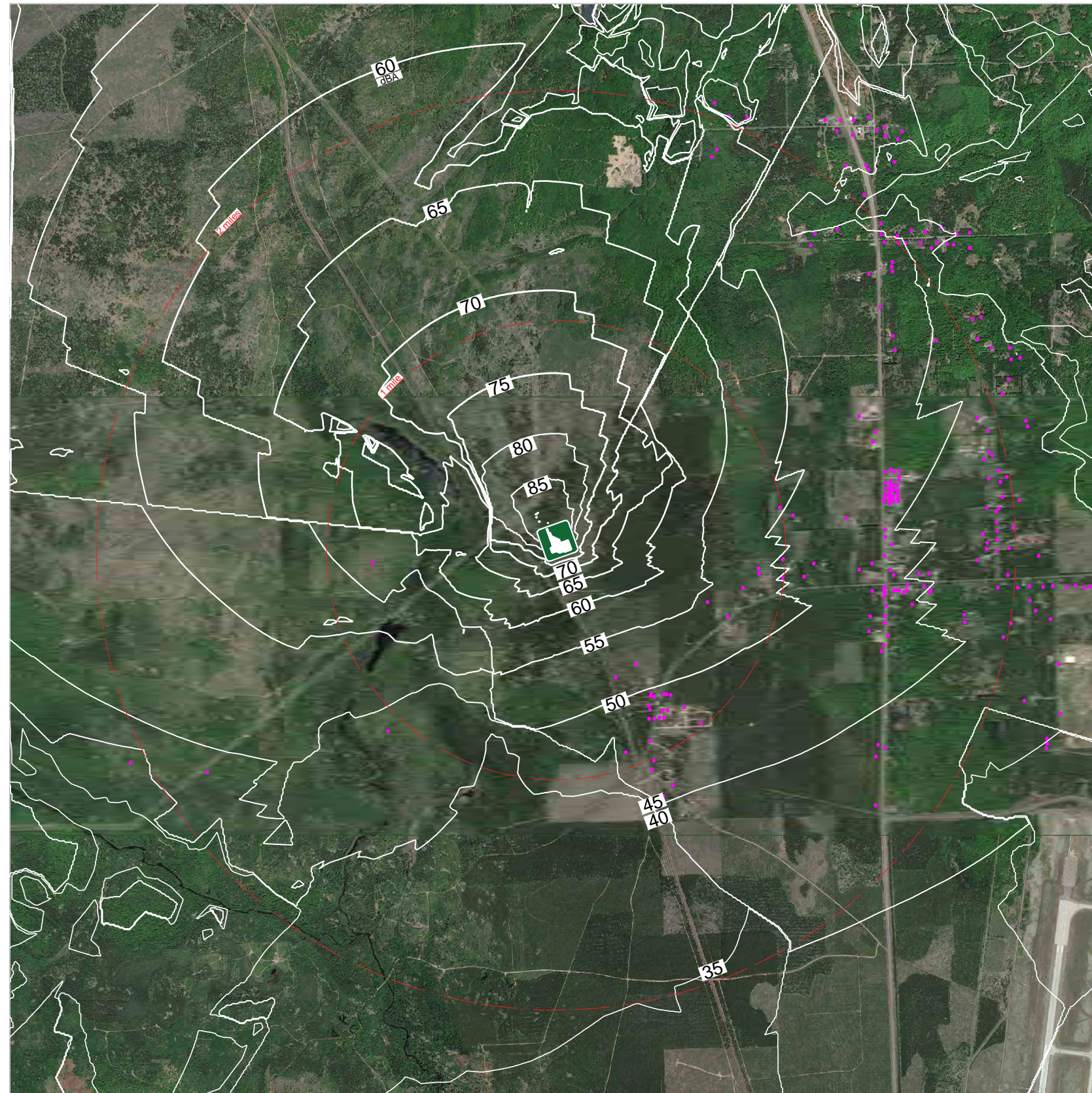
D.O.F. N

Wind: 1 to 11 mph downward

50°F and 80% R.H.



Range Structure
 Sound absorbing material on underside of canopy and on diving panels between each firing lane.
 Rear and side walls added to the structure so the firing positions are opened only in D.O.F.



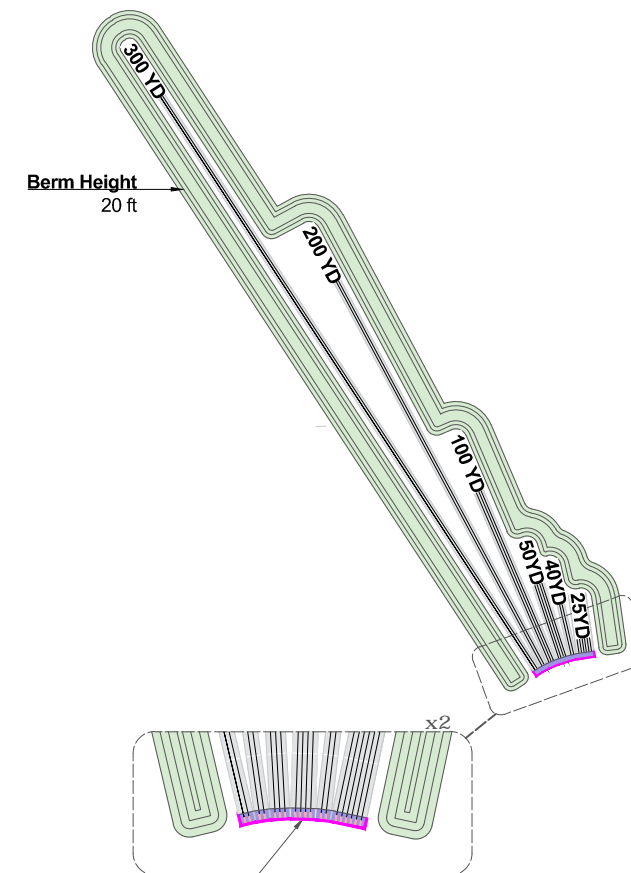
**SANDS
 MODEL M-9**

20 ft. Tall Side Berms
 Sound absorbing canopy and dividers
 Structure with rear and side walls

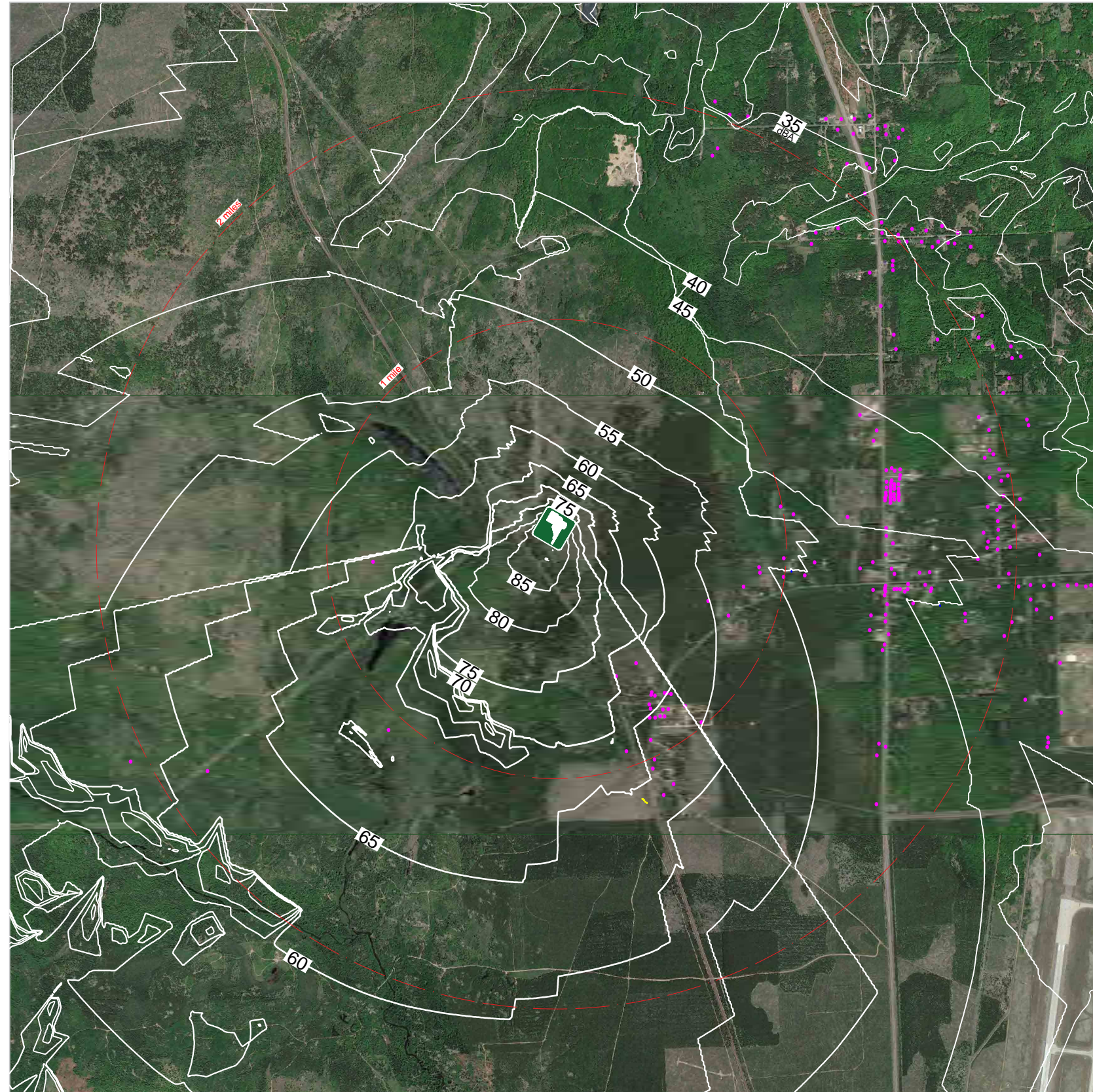
Busy Day:
 Shooters within 1 second:
 3 Rifles
 1 Shotgun
 2 Handguns

D.O.F. NW

Wind: 1 to 11 mph downward
 50°F and 80% R.H.



Range Structure
 Sound absorbing material on underside of canopy and
 on dividing panels between each firing lane.
 Rear and side walls added to the structure so the firing
 positions are opened only in D.O.F.



SANDS
MODEL M-10

20 ft. Tall Side Berms
 Sound absorbing canopy and dividers
 Structure with rear and side walls

Busy Day:
 Shooters within 1 second:
 3 Rifles
 1 Shotgun
 2 Handguns

D.O.F. SW

Wind: 1 to 11 mph downward
 50°F and 80% R.H.

