



Nevada Bureau of Mines and Geology Report 54

Preliminary Assessment of Potentially Unreinforced Masonry Buildings in Nevada

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This report, which is available as an online document at www.nbmng.unr.edu, is a preliminary assessment of potentially unreinforced masonry buildings (URMs) in Nevada. These are the buildings that are highly susceptible to collapse or partial collapse during earthquakes and are therefore of concern for life safety and economic recovery. Data are compiled from information provided by county assessors' offices and the Public Works Division of the State of Nevada with assumptions that potential URMs are those brick, stone, or cement-block masonry buildings that were constructed before 1974. There are tens of thousands of potential URMs in Nevada. They are located in every county and nearly every community. Many URMs are historically significant, and many are concentrated in downtown business districts and along thoroughfares. It is important to note that not all Nevada URMs have been identified in this study, and some structures identified as potential URMs may not be. Risks from URMs can be reduced by removing the buildings, seismic rehabilitating them, and minimizing human occupancy. Major recommendations include:

- (1) Jurisdictions (cities, counties, the State of Nevada, tribes, and the federal government) should follow up with on-the-ground inspections and checks of building plans. Individuals should determine if their buildings are URMs.
- (2) Jurisdictions should work toward seismically rehabilitating URMs or removing them from human occupancy.

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The Nevada Bureau of Mines and Geology (NBMG) is a research and public service unit of the University of Nevada, Reno and is the State geological survey. Established by the Nevada Legislature as a department within the public service division of the Nevada System of Higher Education, NBMG is part of the Mackay School of Earth Sciences and Engineering within the College of Science and one of the Statewide Programs at the University of Nevada, Reno. NBMG's mission, to provide the State's needs for geological and mineral-resource information and research, is defined in its enabling legislation. NBMG scientists conduct research and publish reports that focus on the economic development, public safety, and quality of life in urban and rural areas of Nevada.

Introduction

Unreinforced masonry (URM) buildings (URMs) are typically the buildings most likely to partially or completely collapse during earthquakes, according to the Federal Emergency Management Agency (FEMA, 2009). These are masonry (generally brick, concrete block, clay tile, stone, or adobe) buildings that contain no structural steel or other reinforcement in them. The masonry walls alone bear the load or weight of the building. During earthquakes and aftershocks, heavy material falling from walls, roofs, ceilings, parapets, facades, and chimneys cause damage to property and injure or kill people both inside and outside URMs.

Nevada has had many major earthquakes in the past, and URMs have been damaged or collapsed during many of the historical events (table 1). The 2008 M 6.0 Wells earthquake (figures 1 through 4), which caused partial to total collapse and significant damage both inside and outside of URMs, but fortunately no deaths, reminded us that major earthquakes can occur even in the areas with lower risk than the most hazardous parts of the State (figure 5). As demonstrated by both the historical seismicity (dePolo and dePolo, 2012) and the geological record of significant earthquakes in prehistoric times (dePolo, 2008), major earthquakes capable of collapsing URMs can occur anywhere in Nevada.

Table 1. Selected historical Nevada earthquakes during which URMs were damaged (from dePolo, 2012).

Year	Magnitude	Earthquake	Nearest community
1915	7.3	Pleasant Valley	Winnemucca
1932	7.1	Cedar Mountain	Mina
1948	~6	Verdi	Verdi/Reno
1954	6.2	Rainbow Mountains	Fallon
1954	6.8	Stillwater	Fallon
1954	7.1	Fairview Peak	Fallon
1954	6.9	Dixie Valley	Fallon
2008	6.0	Wells	Wells



Figure 1. Front of the two-story San Marin Hotel, before the 2008 Wells earthquake. Photo by ExploreNevada.com (from dePolo and LaPointe, 2011).



Figure 2. Front of the San Marin Hotel, after the 2008 Wells earthquake. Photo by C.M. dePolo (from dePolo and LaPointe, 2011). Note the brick debris that fell to the sidewalk in front of the building. The earthquake occurred at 6:16 a.m. local time, and fortunately nobody was on the sidewalk at that time.



Figure 3. Back of the San Marin Hotel, after the 2008 Wells earthquake. Photo by C.M. dePolo (from dePolo and LaPointe, 2011).

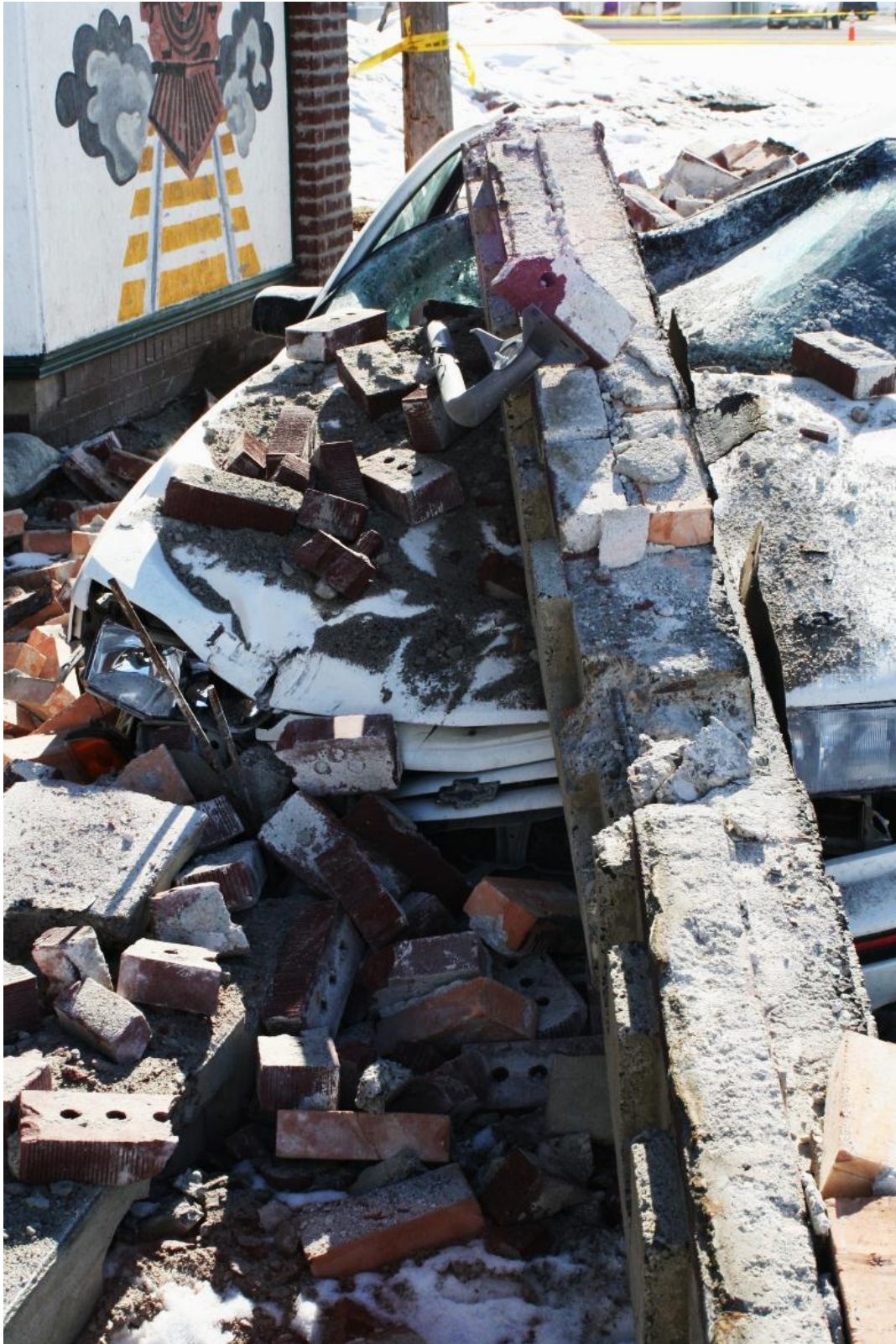


Figure 4. One of the most damaging components of a URM is a concrete crowning bond beam that commonly caps brick walls. These beams add momentum to the top of the wall during shaking and commonly fail in large sections, creating a concentrated destructive force. This photograph, taken from the 2008 Wells earthquake, shows a crowning bond beam that fell on a car. Photo by C.M. dePolo (from dePolo and LaPointe, 2011).

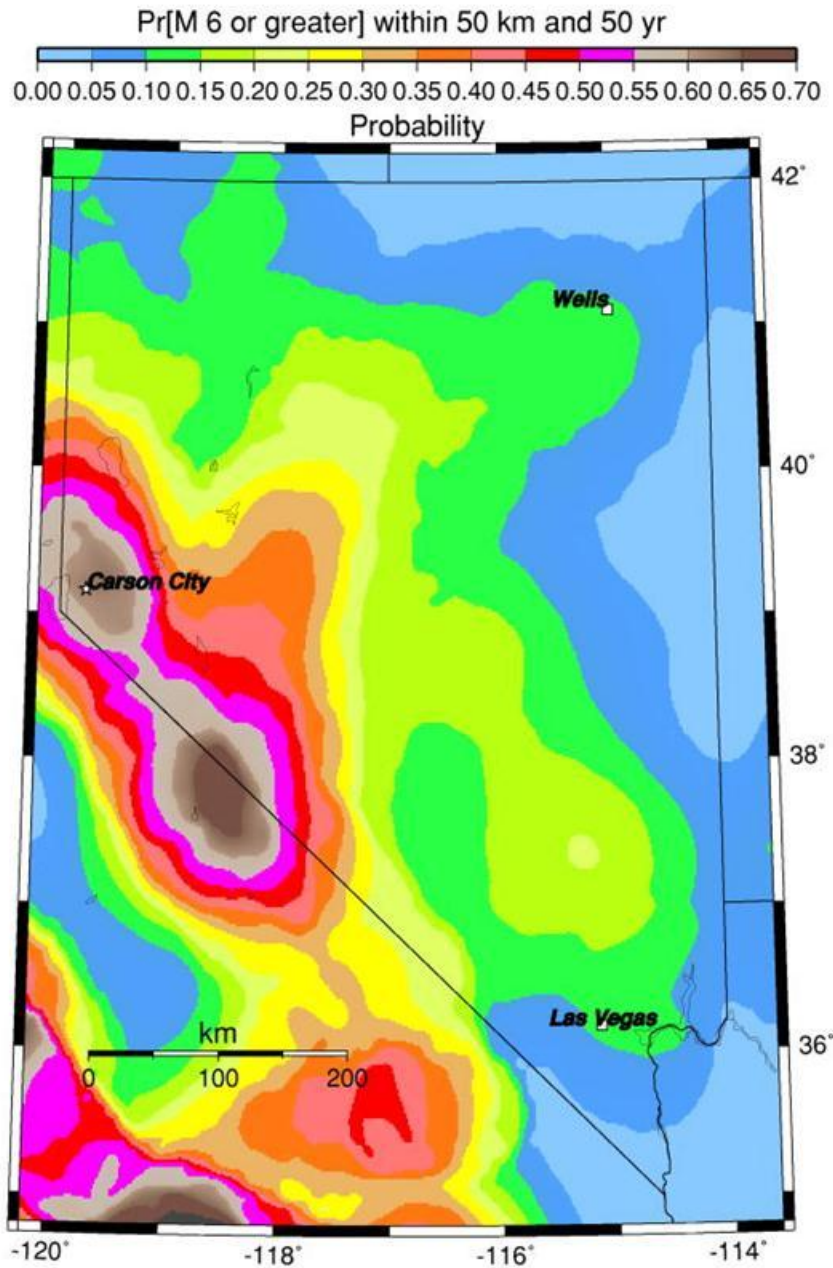


Figure 5. Map by the U.S. Geological Survey showing probability of an earthquake of magnitude 6.0 (the size of the 21 February 2008 Wells earthquake) or greater occurring within 50 kilometers (31 miles) in 50 years (from dePolo and LaPointe, 2011). Note that the hazard for Las Vegas is comparable to that for Wells.

In its Policy Recommendation 11-4, the Western States Seismic Policy Council (WSSPC) states “Unreinforced masonry bearing-wall structures represent one of the greatest life-safety threats and economic burdens to the public during a damaging earthquake. WSSPC recommends that each state, province or territory adopt a program to identify the extent of risk that unreinforced masonry structures represent in their communities and develop recommendations that will effectively address the reduction of this risk.”

Methods

To address URMs in Nevada, the Nevada Earthquake Safety Council endorsed this WSSPC policy recommendation and encouraged the completion of a preliminary assessment of the possible problem. Members of the Council who are familiar with structural engineering and building codes suggested that potentially unreinforced masonry buildings be defined as those buildings with brick, stone, or block masonry construction listed by county assessors or the State Public Works Division as built before 1974, by which time most local jurisdictions had adopted building codes that prohibited construction of URMs.

The Nevada Division of Emergency Management secured funding from FEMA to help with the effort, and the Nevada Public Agency Insurance Pool provided matching funds and access to the databases of the county assessors throughout the State. Using the definition of potential URMs, the Nevada Bureau of Mines and Geology selected buildings from the assessors' databases to create a new database of potential URMs statewide, added to the database the potential URMs identified by the State Public Works Division, compiled the statistics in this report, created maps of potential URMs in each county and several cities using geographic information system (GIS) technology, and created a web service for easy viewing of the information in map format.

Caution is needed in using this information, because we know that there are errors in the database. Correcting the errors, which was well beyond the scope of this work, is one of the recommendations at the end of this report. On the basis of limited on-the-ground inspections and general knowledge, we know that there are the following types of errors in the database:

- Some URMs have been missed. We know that some buildings that are clearly old, masonry structures are missing from the assessors' databases. This is definitely the case in Virginia City, Storey County. In addition, buildings owned by the federal government and buildings on tribal lands are not included in this preliminary assessment.
- Some buildings may have been counted as URMs because their building types were listed inaccurately in the assessors' databases.
- Some URMs have been misidentified or inaccurately located because address coding in the assessors' databases was inaccurate.
- Some buildings may have been included as URMs because of lack of an accurate construction date in the assessors' databases.
- Some buildings may have been seismically rehabilitated and should no longer be considered URMs.
- Some URMs have been removed and should no longer be in the databases.

Results

This report contains maps of each county and some cities and towns showing the general location of potential URMs in Nevada (figures 6 through 46). Three categories of buildings are listed: (1) Commercial, including private buildings as well as public buildings owned by county and city governments and school districts, (2) State-owned buildings, including those operated by the Nevada System of Higher Education, and (3) Residential buildings. The results are summarized in table 2.

Maps can also be viewed on the web service at http://gisweb.unr.edu/URM_project/. At this website, users can view the maps with a topographic base map, a street base map, or on an aerial photographic base. The map can be viewed at various scales for which the underlying base maps

change to an appropriate view. Properties can be located using an address search. An “Identify” function provides publicly available data on potential URM’s from the county assessors’ databases.

Table 2. Number of potential URM’s in Nevada by county.

<u>County</u>	<u>Commercial & Public</u>	<u>State</u>	<u>Residential</u>	<u>Total[#]</u>
Carson City	487	72	175	734
Churchill	177		192	369
Douglas	114		294	408
Elko	39		23	62
Eureka	0		35	35
Humboldt	192	1	184	377
Lander	57		67	124
Lyon	234	1	175	410
Mineral	60		57	117
Pershing	37		31	68
Storey	3		21	24
Washoe	2,445	21	3,322	5,788
White Pine	<u>138</u>	<u>1</u>	<u>93</u>	<u>232</u>
Subtotal, N. Nevada	3,983	96	4,669	8,748
Clark	11,963		2,396	14,359
Esmeralda	2		14	16
Lincoln	53	2	47	102
Nye	<u>144</u>		<u>228</u>	<u>372</u>
Subtotal, S. Nevada	12,162	2	2,685	14,849
All of Nevada	16,145	98	7,354	23,597

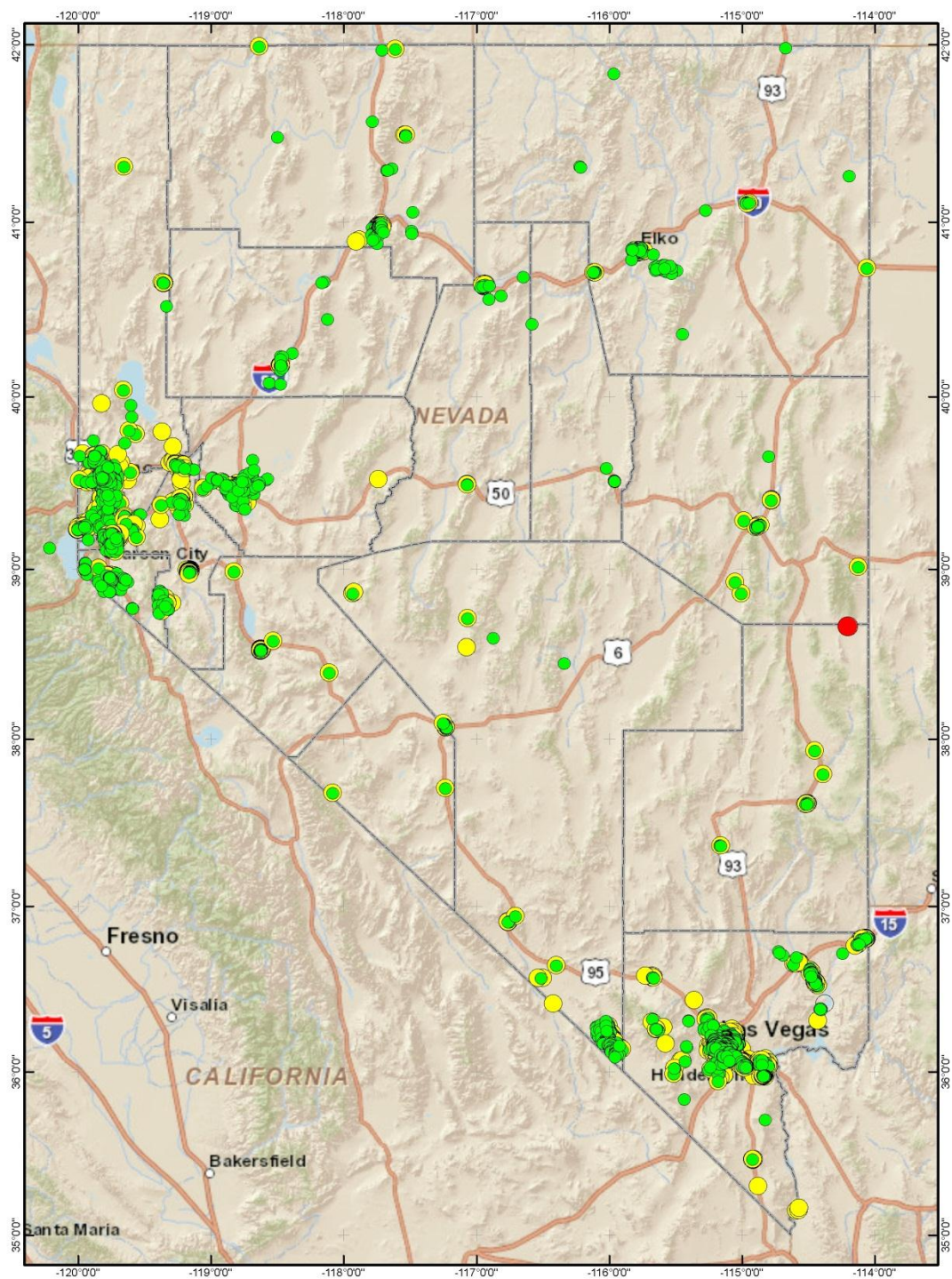


Figure 6. Potential URMs in Nevada (23,597 total). Residential buildings are plotted in green; commercial buildings are plotted in yellow; State-owned buildings are plotted in red. Note that yellow is plotted over and masks red, and green is plotted over and masks yellow.

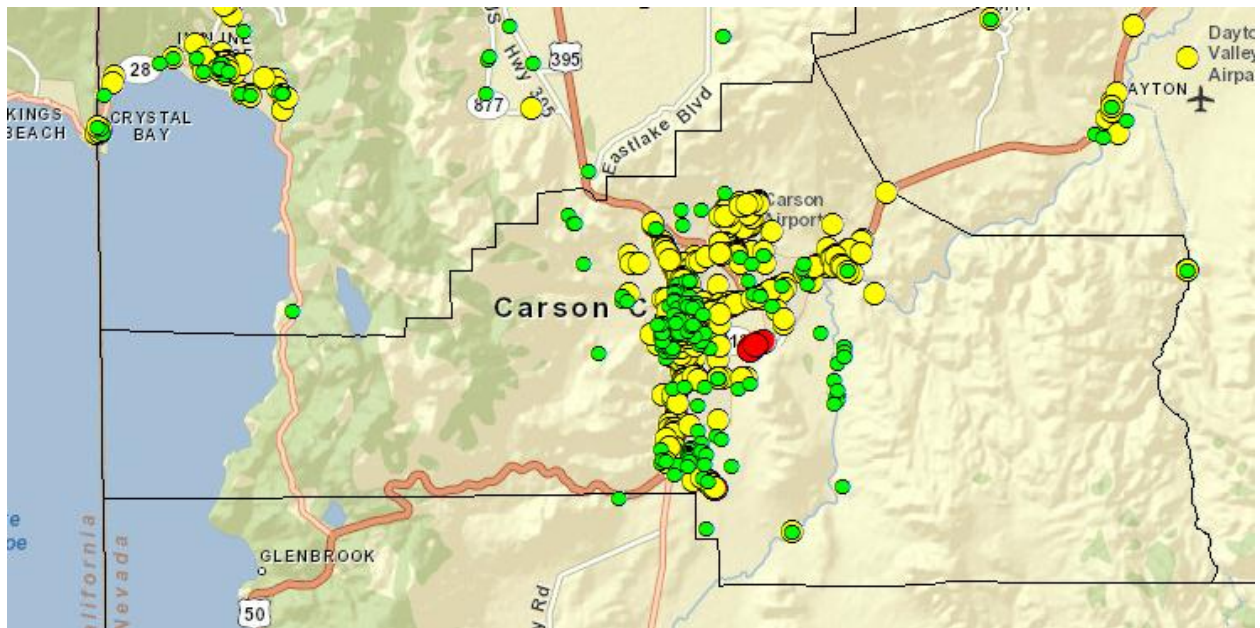


Figure 7. Potential URMs in Carson City (734 total). Residential buildings are plotted in green; commercial buildings are plotted in yellow; State-owned buildings are plotted in red. Note that yellow is plotted over and masks red, and green is plotted over and masks yellow.

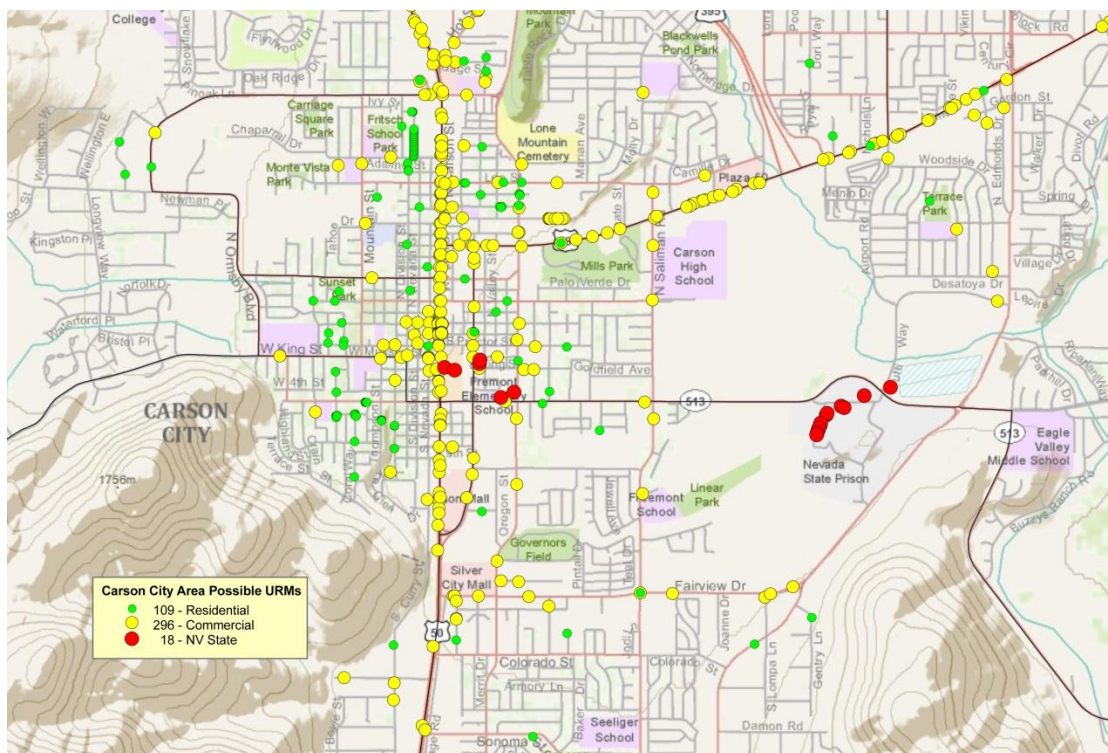


Figure 8. Potential URMs in the Carson City area. Residential buildings are plotted in green; commercial buildings are plotted in yellow; State-owned building are plotted in red. Note that green is plotted over and masks yellow, and red is plotted over and masks both green and yellow. The base map is a U.S. Geological Survey topographic map.

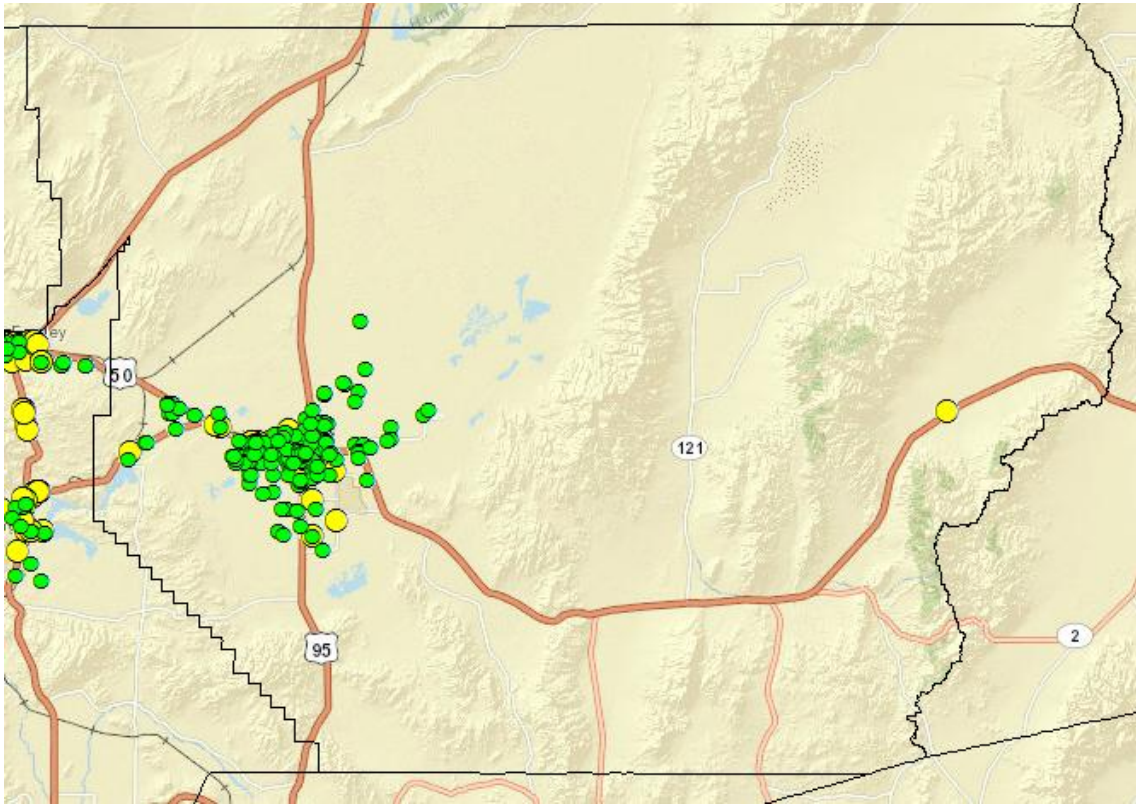


Figure 9. Potential URMs in Churchill County (369 total). Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow.

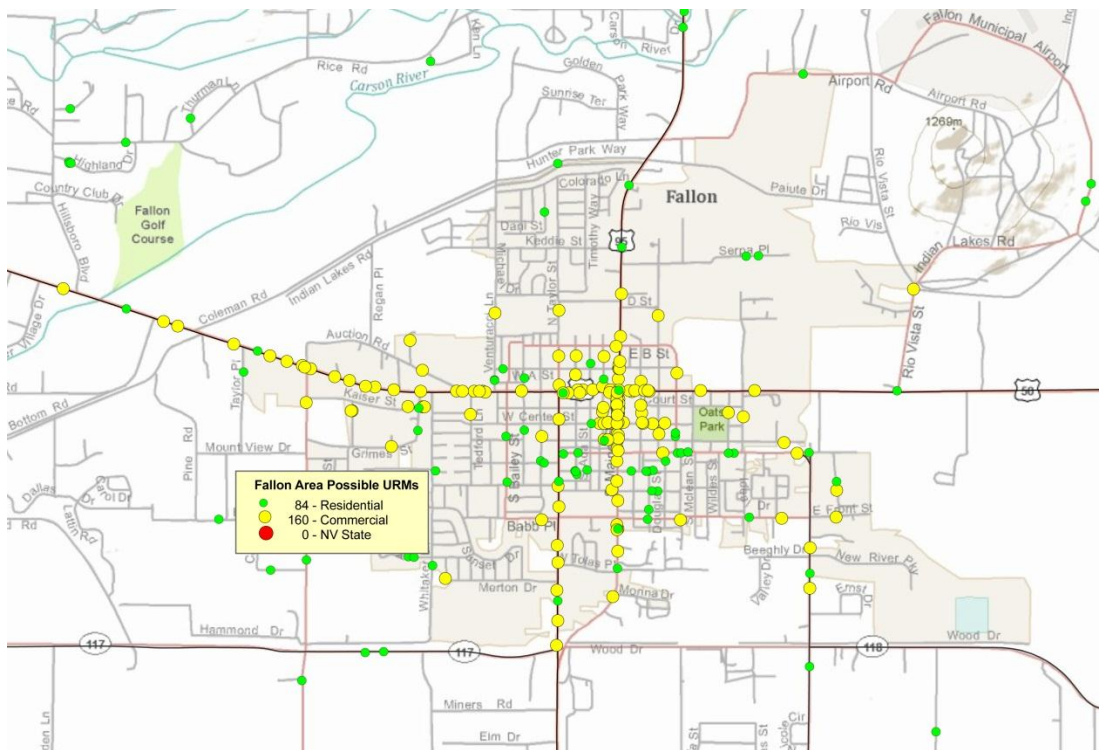


Figure 10. Potential URMs in the Fallon area. Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow. The base map is a U.S. Geological Survey topographic map.

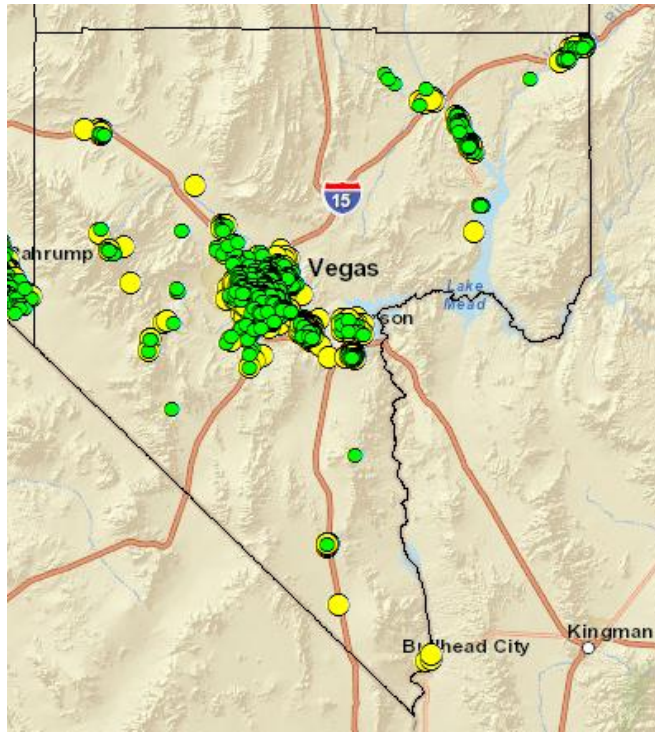


Figure 11. Potential URMs in Clark County (14,359 total). Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow.

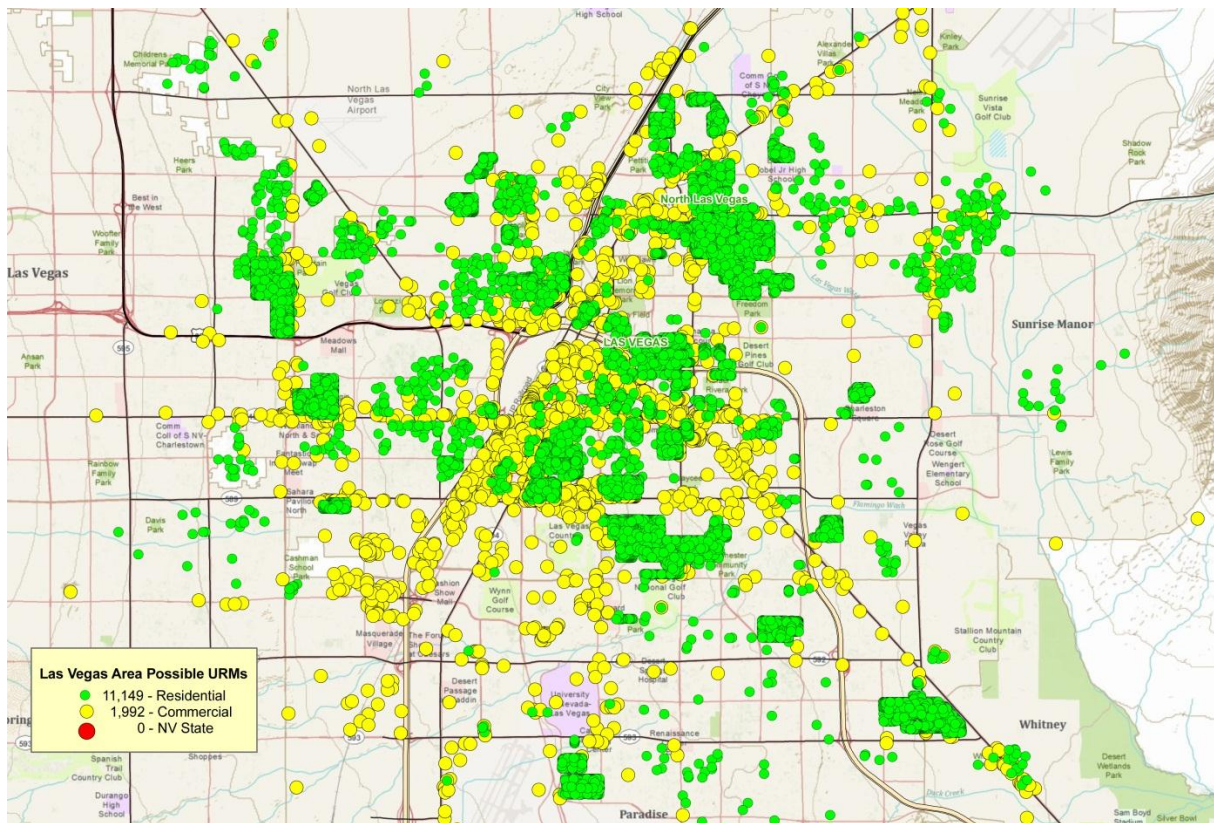


Figure 12. Potential URMs in the Las Vegas area. Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow. The base map is a U.S. Geological Survey topographic map.

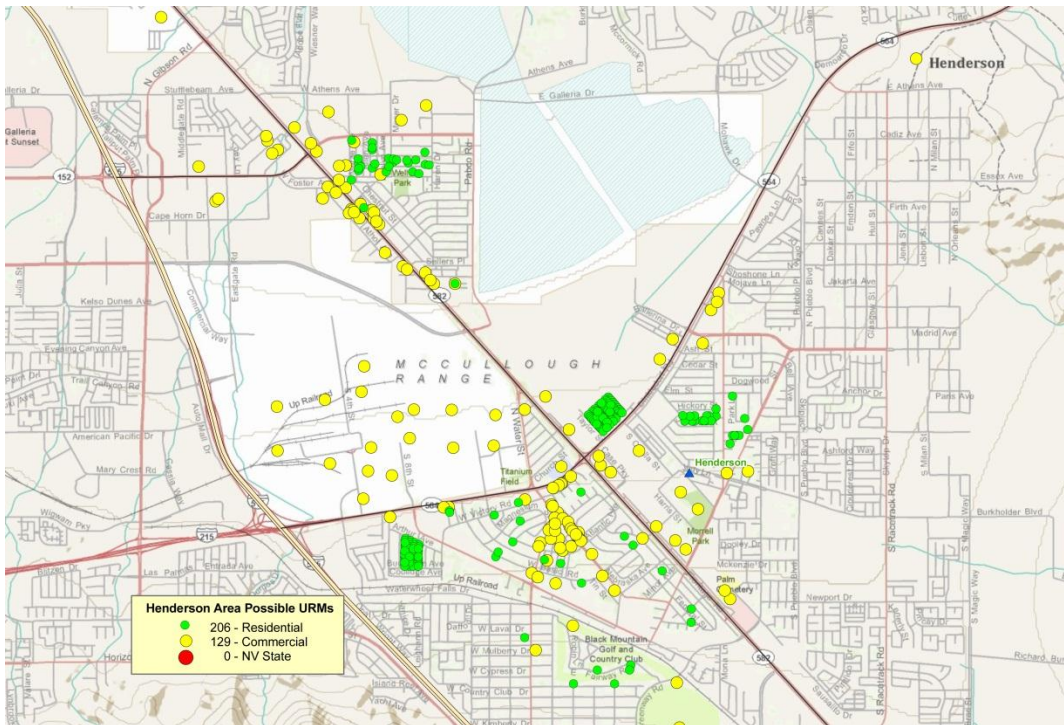


Figure 13. Potential URMs in the Henderson area. Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow. The base map is a U.S. Geological Survey topographic map.

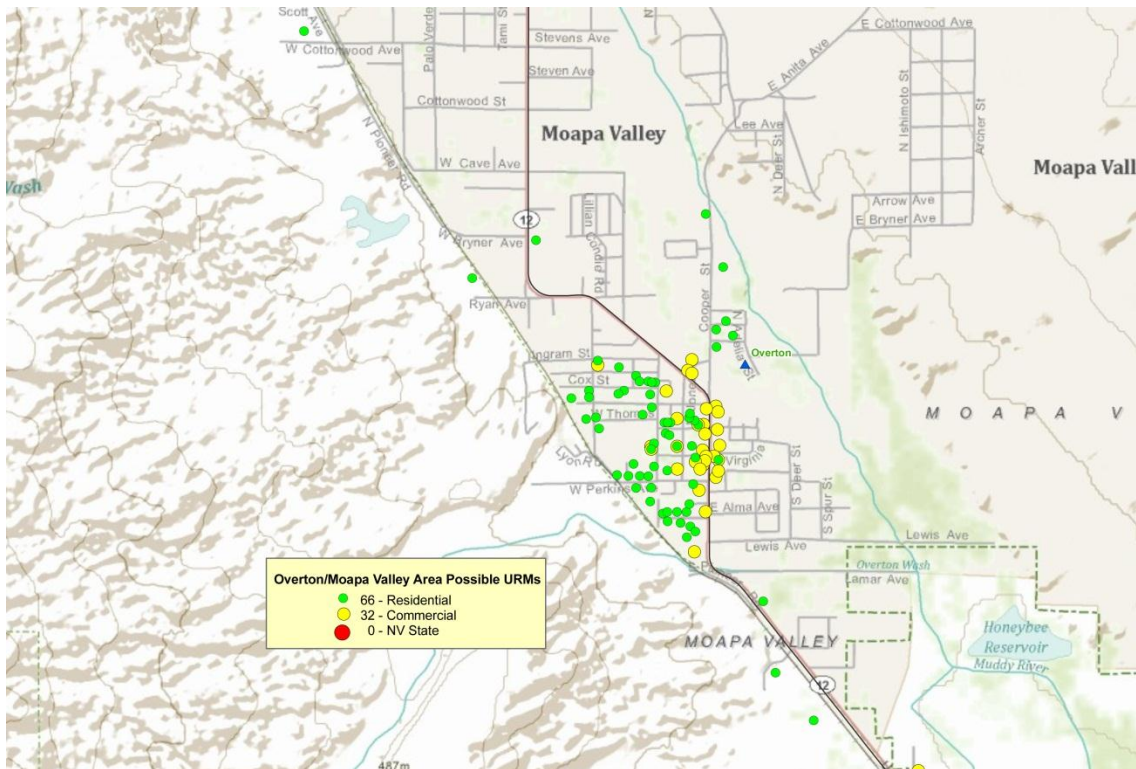


Figure 14. Potential URMs in the Overton area. Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow. The base map is a U.S. Geological Survey topographic map.

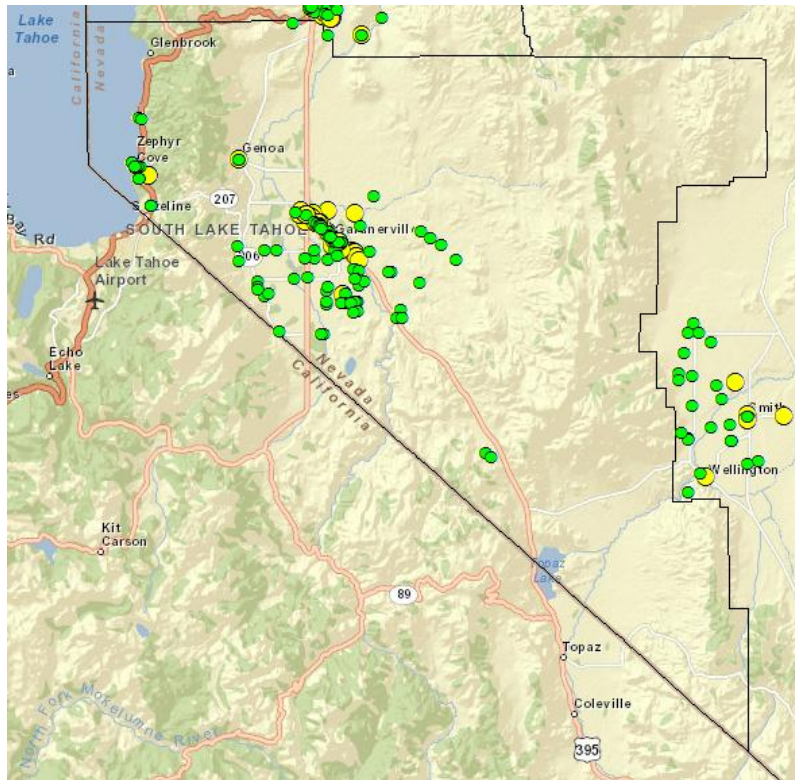


Figure 15. Potential URMs in Douglas County (408 total). Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow.

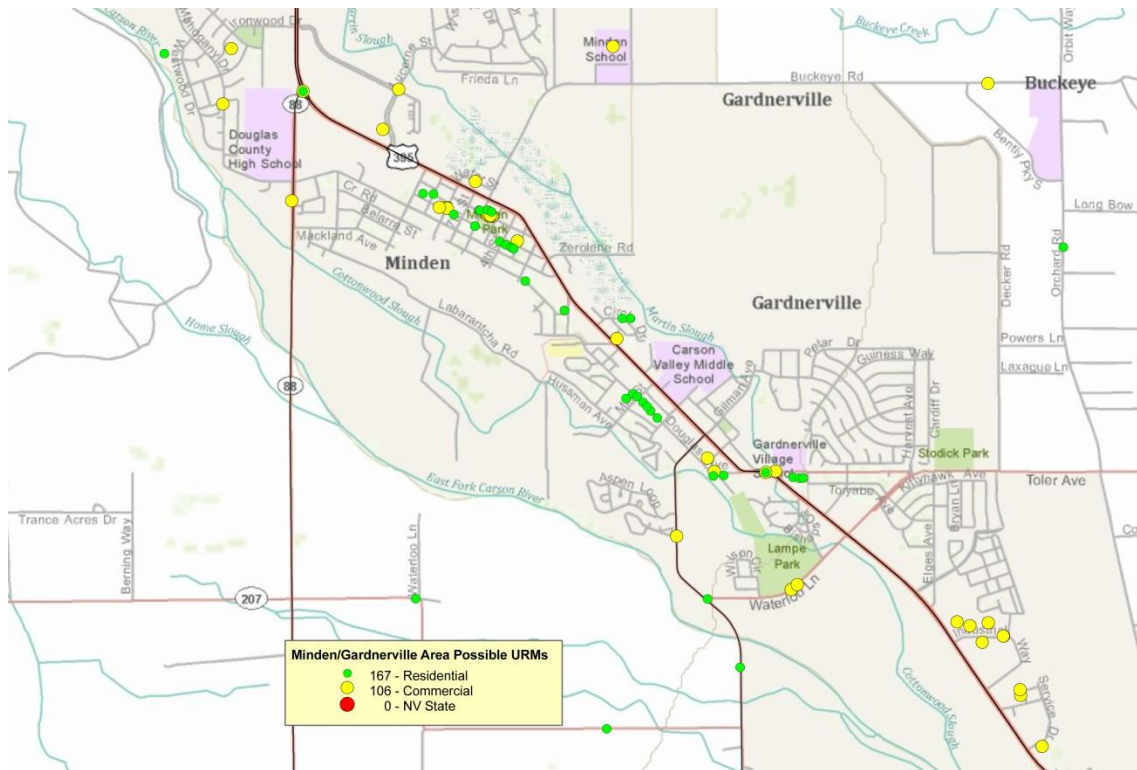


Figure 16. Potential URMs in the Minden-Gardnerville area. Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow. The base map is a U.S. Geological Survey topographic map.

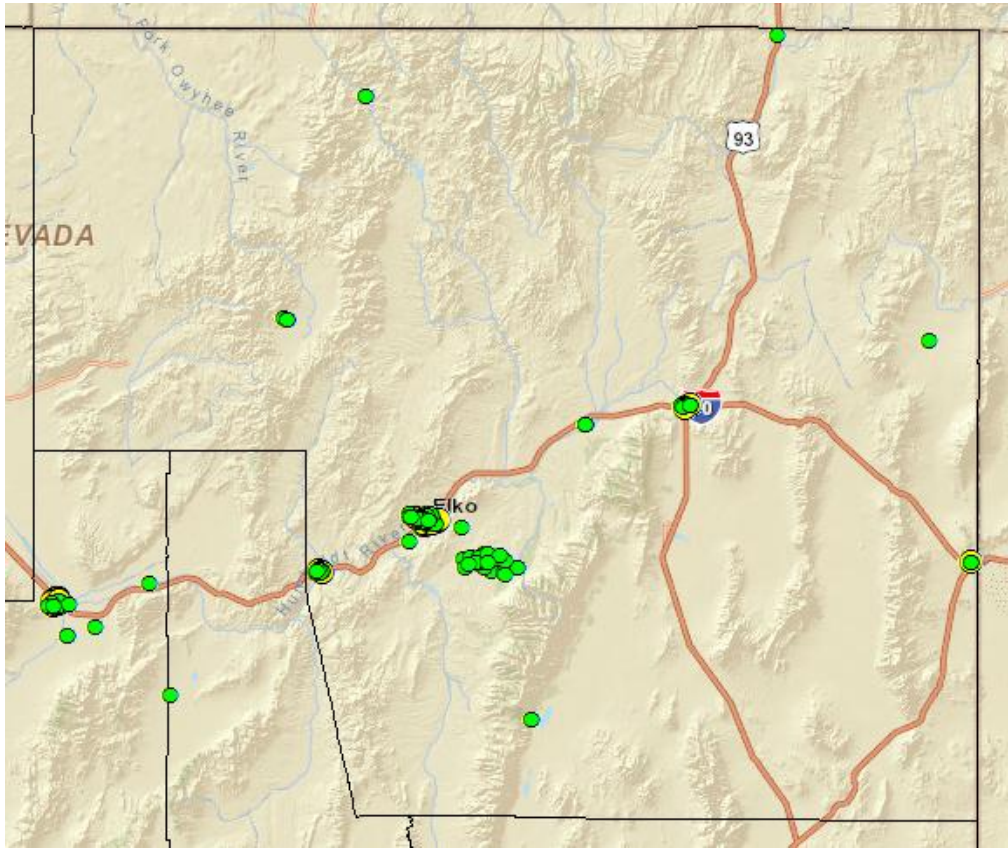


Figure 17. Potential URMs in Elko County (62 total). Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow.

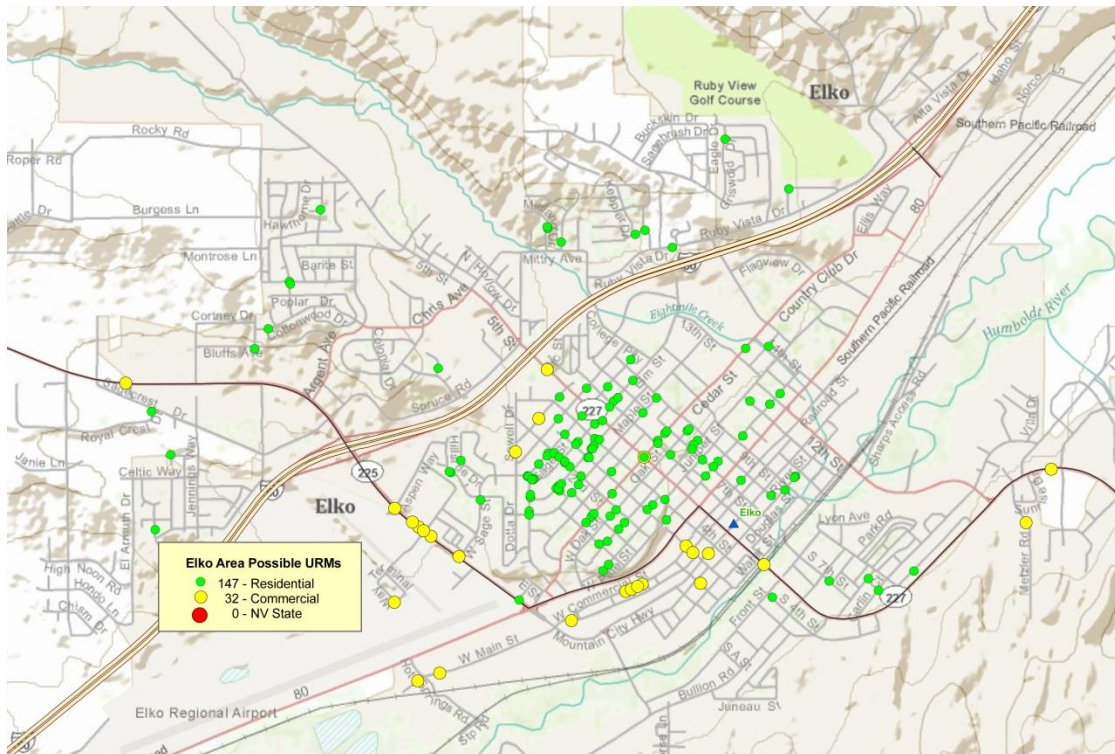


Figure 18. Potential URMs in the Elko area. Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow. The base map is a U.S. Geological Survey topographic map.

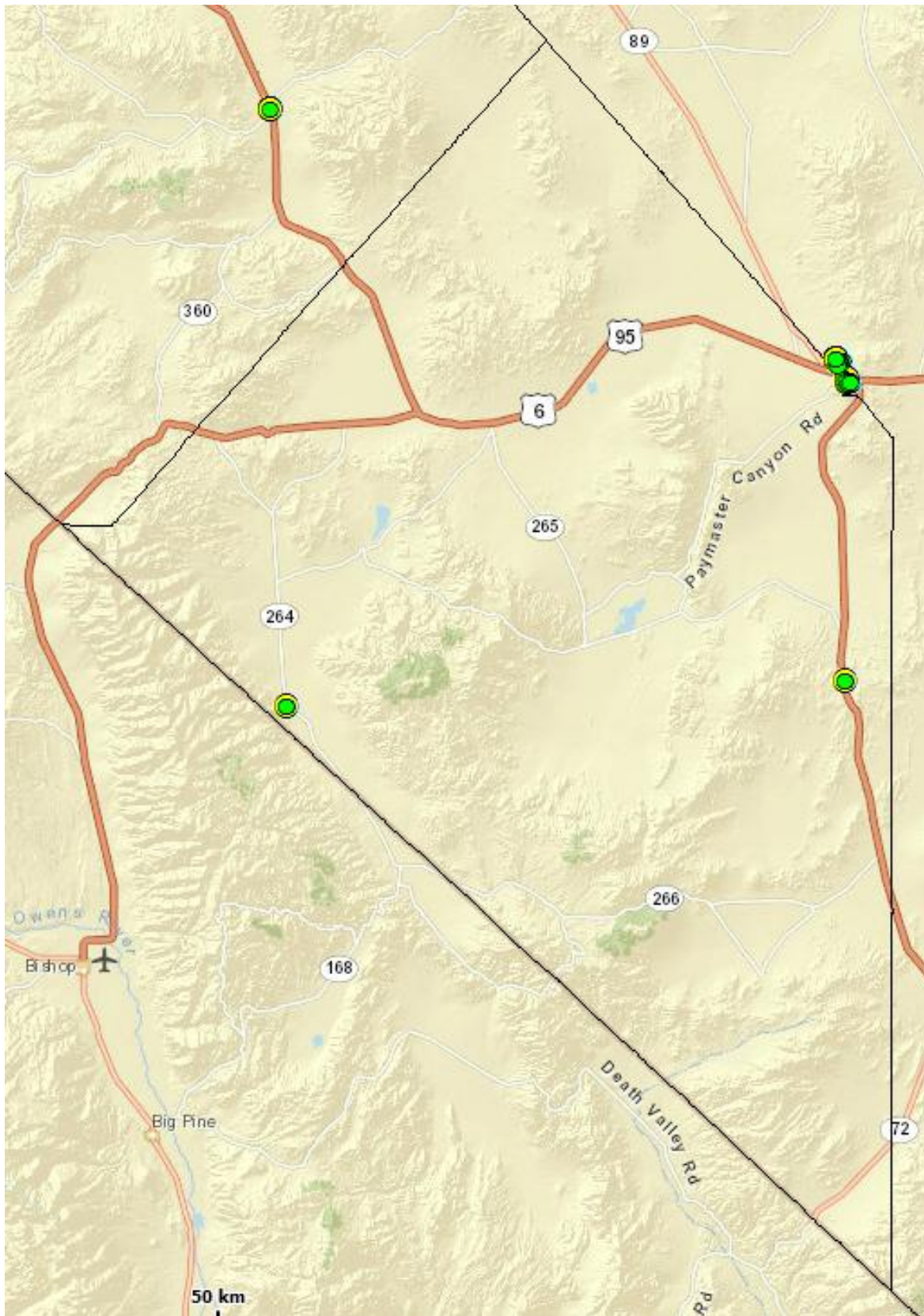


Figure 19. Potential URMs in Esmeralda County (16 total). Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow.

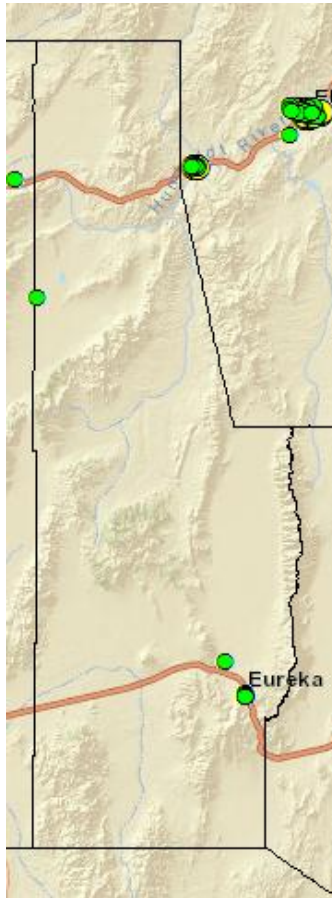


Figure 20. Potential URMs in Eureka County (35 total). Residential buildings are plotted in green.

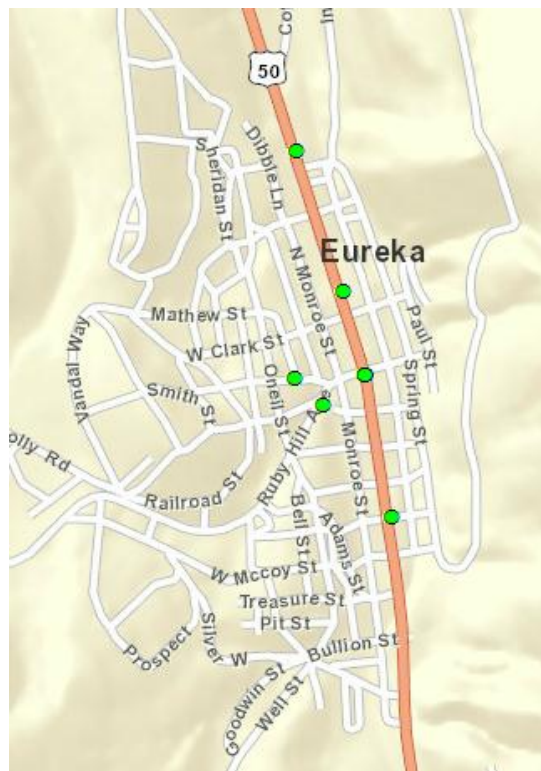


Figure 21. Potential URMs in Eureka. Residential buildings are plotted in green.

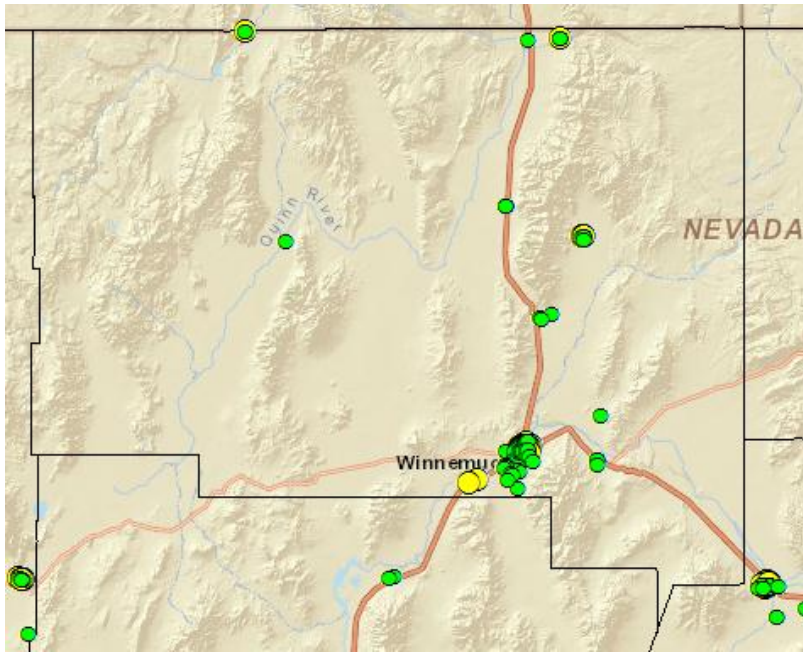


Figure 22. Potential URMs in Humboldt County (377 total). Residential buildings are plotted in green; commercial buildings are plotted in yellow; State-owned buildings are plotted in red. Note that yellow is plotted over and masks red, and green is plotted over and masks yellow.

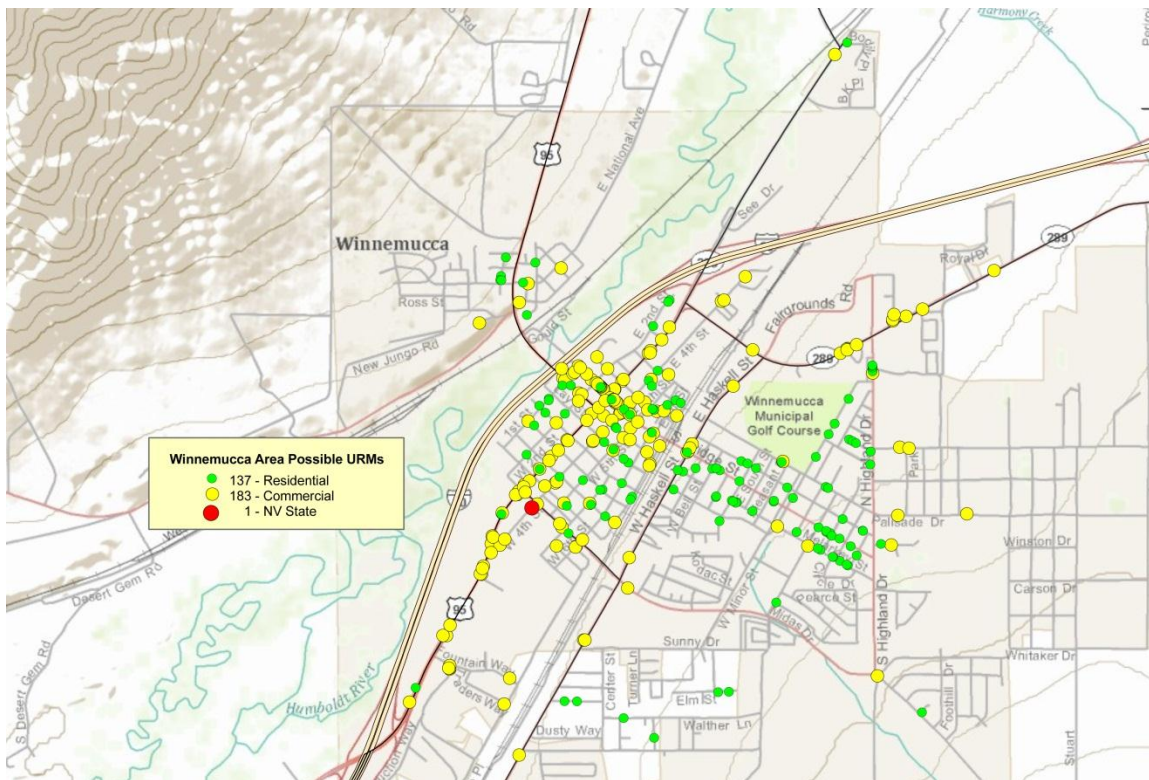


Figure 23. Potential URMs in the Winnemucca area. Residential buildings are plotted in green; commercial buildings are plotted in yellow; State-owned building are plotted in red. Note that green is plotted over and masks yellow, and red is plotted over and masks both green and yellow. The base map is a U.S. Geological Survey topographic map.

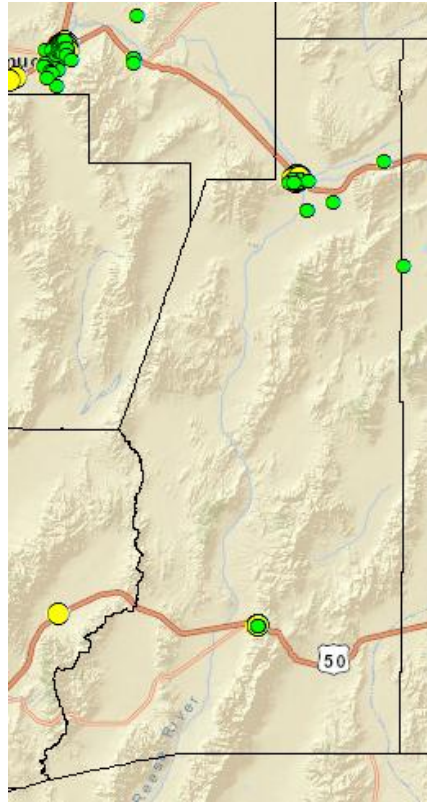


Figure 24. Potential URMs in Lander County (124 total). Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow.

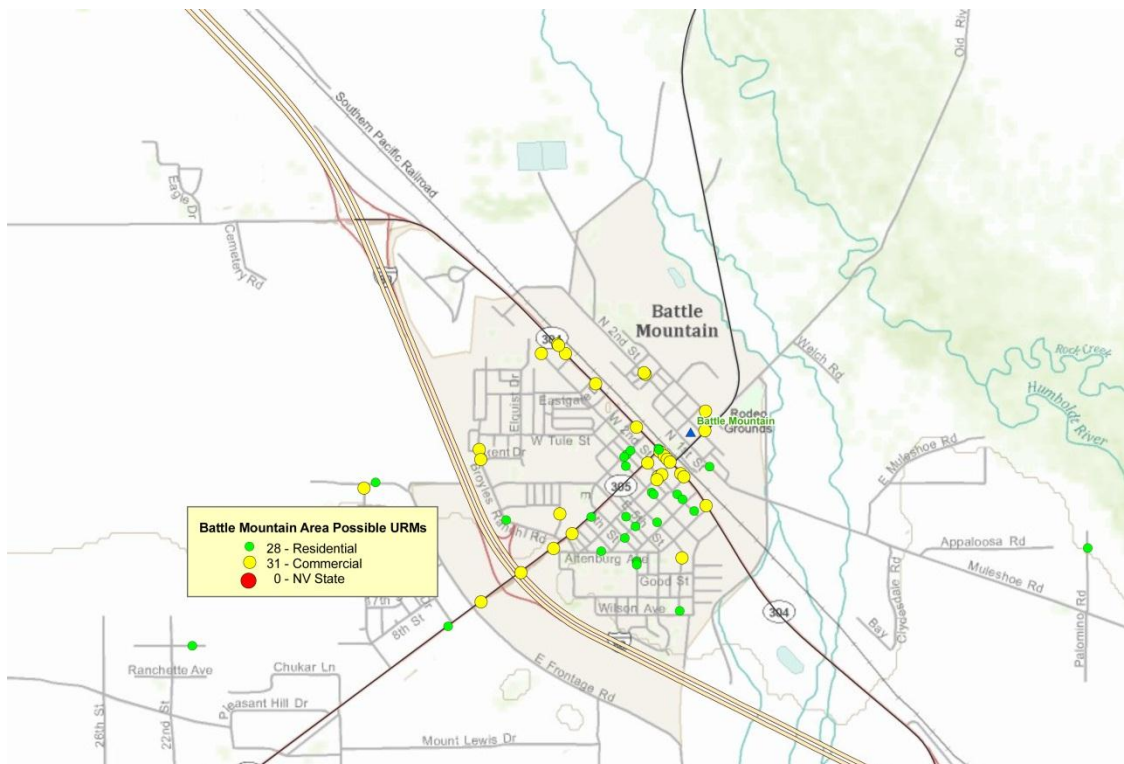


Figure 25. Potential URMs in the Battle Mountain area. Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow. The base map is a U.S. Geological Survey topographic map.

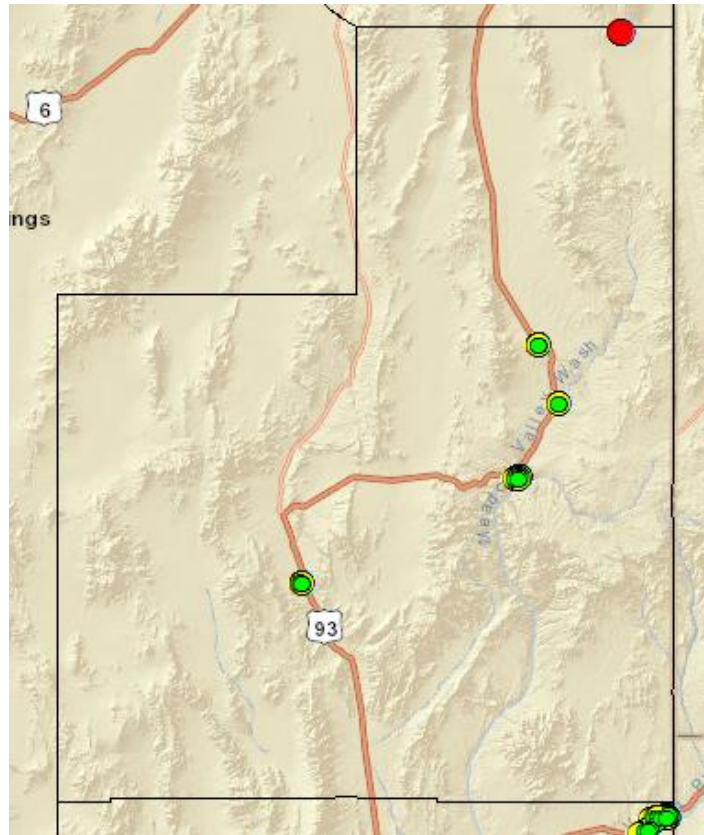


Figure 26. Potential URMs in Lincoln County (102 total). Residential buildings are plotted in green; commercial buildings are plotted in yellow; State-owned buildings are plotted in red. Note that yellow is plotted over and masks red, and green is plotted over and masks yellow.

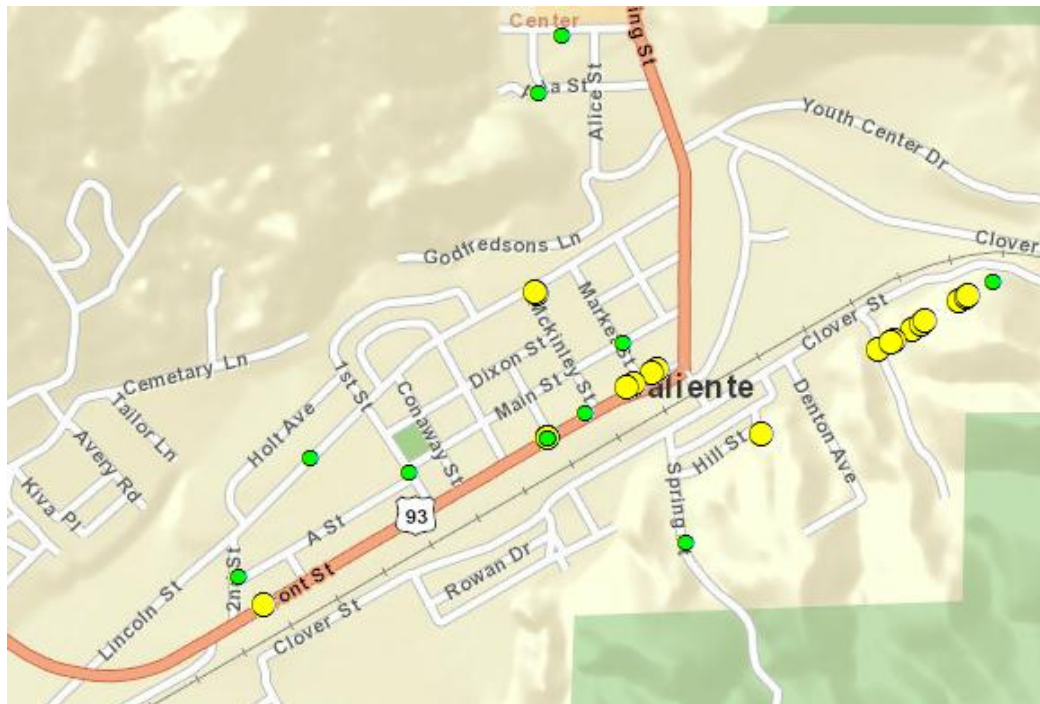


Figure 27. Potential URMs in Caliente. Residential buildings are plotted in green; commercial buildings are plotted in yellow; State-owned buildings are plotted in red. Note that yellow is plotted over and masks red, and green is plotted over and masks yellow.

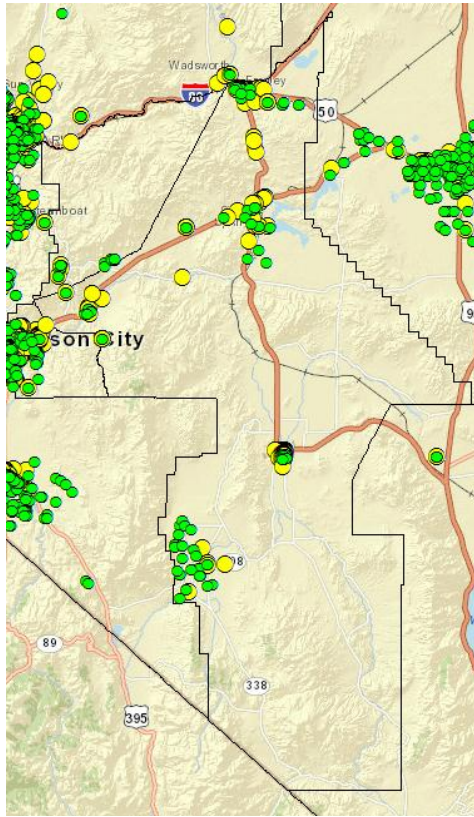


Figure 28. Potential URMs in Lyon County (410 total). Residential buildings are plotted in green; commercial buildings are plotted in yellow; State-owned buildings are plotted in red. Note that yellow is plotted over and masks red, and green is plotted over and masks yellow.

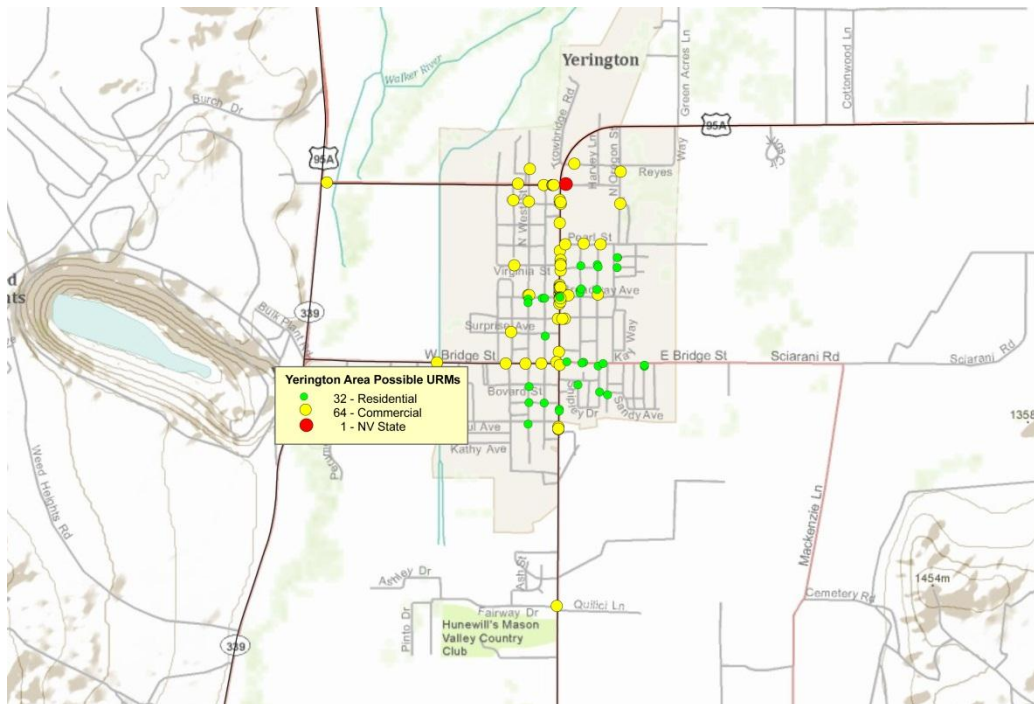


Figure 29. Potential URMs in the Yerington area. Residential buildings are plotted in green; commercial buildings are plotted in yellow; State-owned building are plotted in red. Note that green is plotted over and masks yellow, and red is plotted over and masks both green and yellow. The base map is a U.S. Geological Survey topographic map.

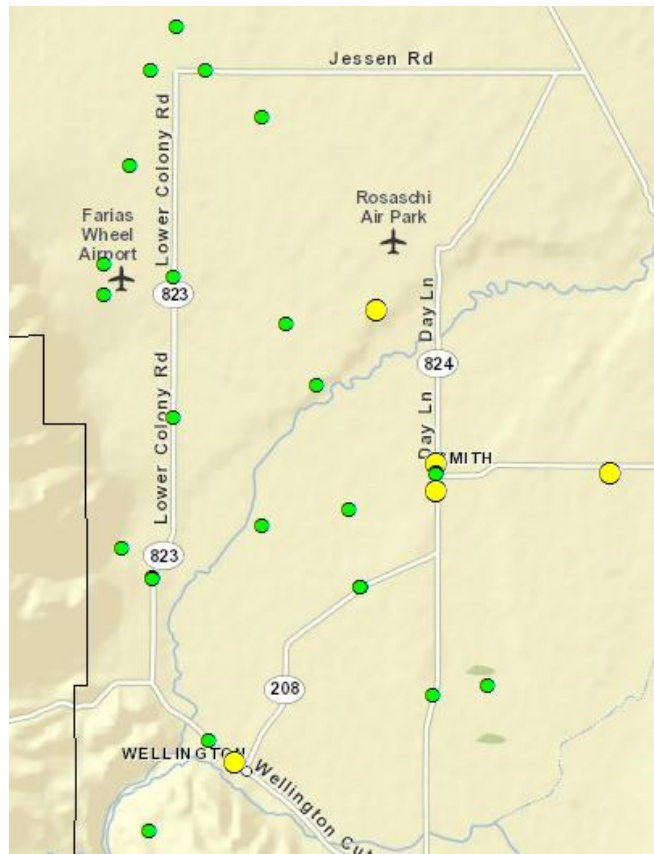


Figure 30. Potential URMs in Smith Valley. Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow.

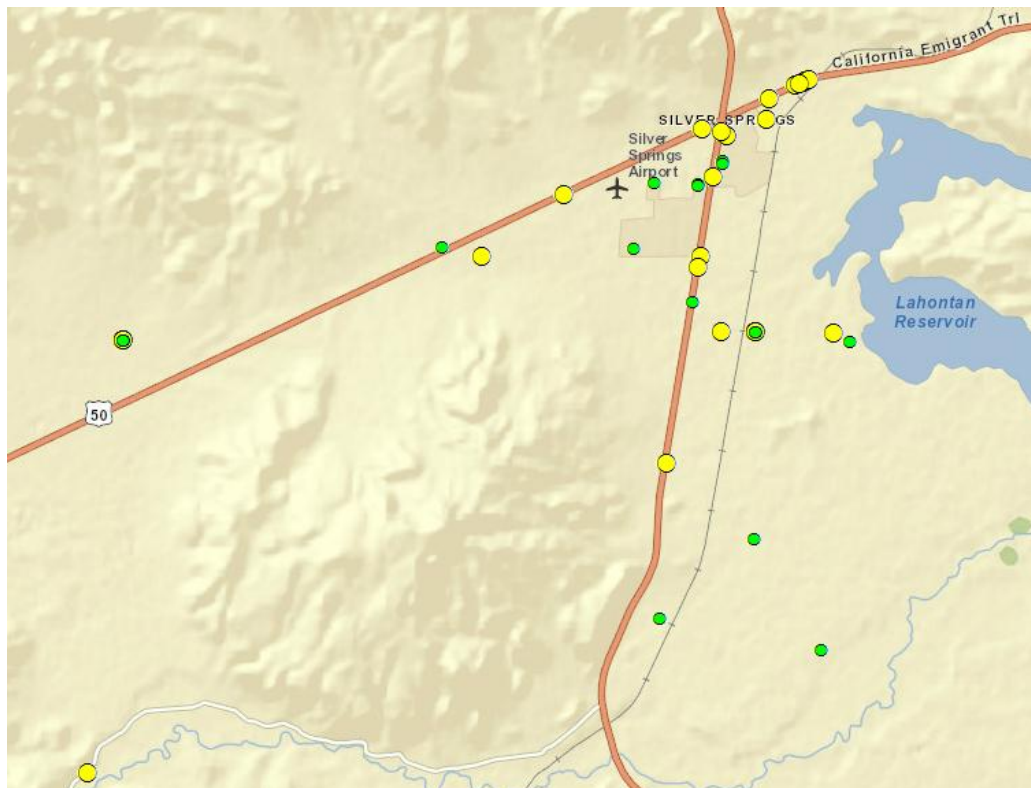


Figure 31. Potential URMs in the Silver Springs area. Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow.



Figure 32. Potential URM's in the Fernley-Wadsworth area. Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow. The base map is a U.S. Geological Survey topographic map.

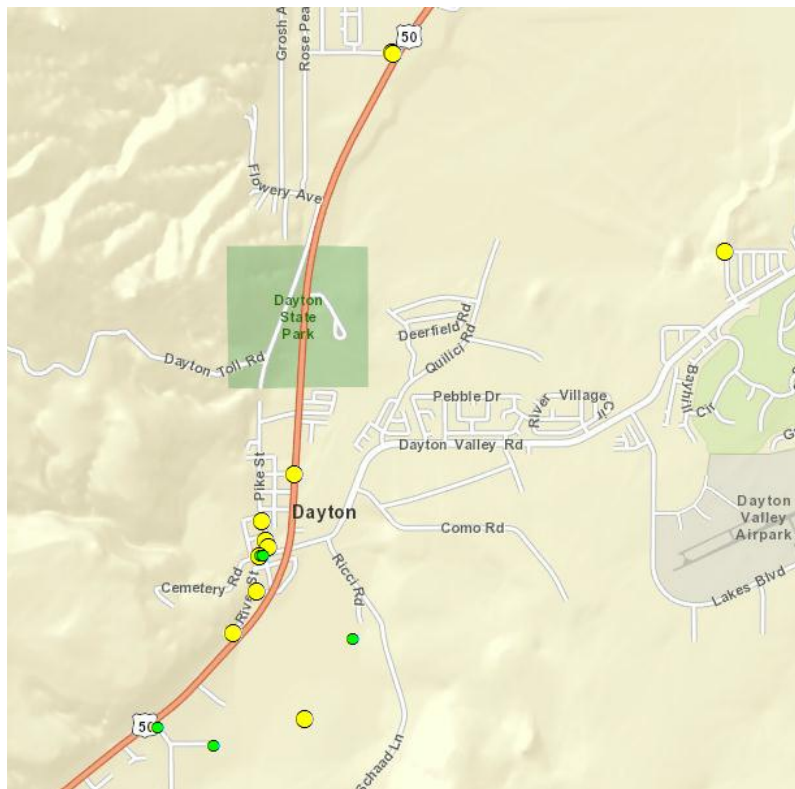


Figure 33. Potential URM's in Dayton. Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow.

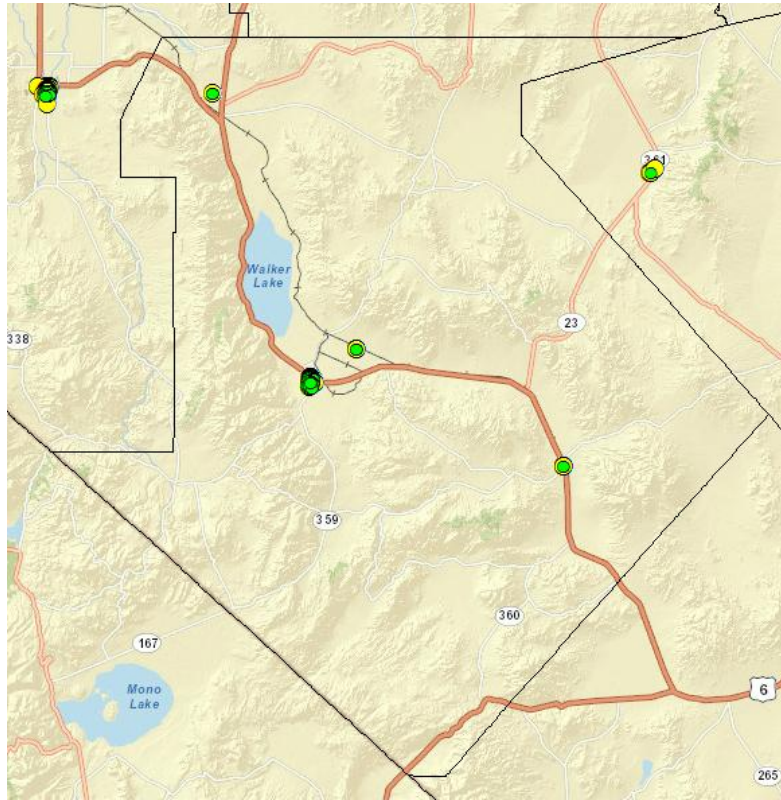


Figure 34. Potential URMs in Mineral County (117 total). Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow.

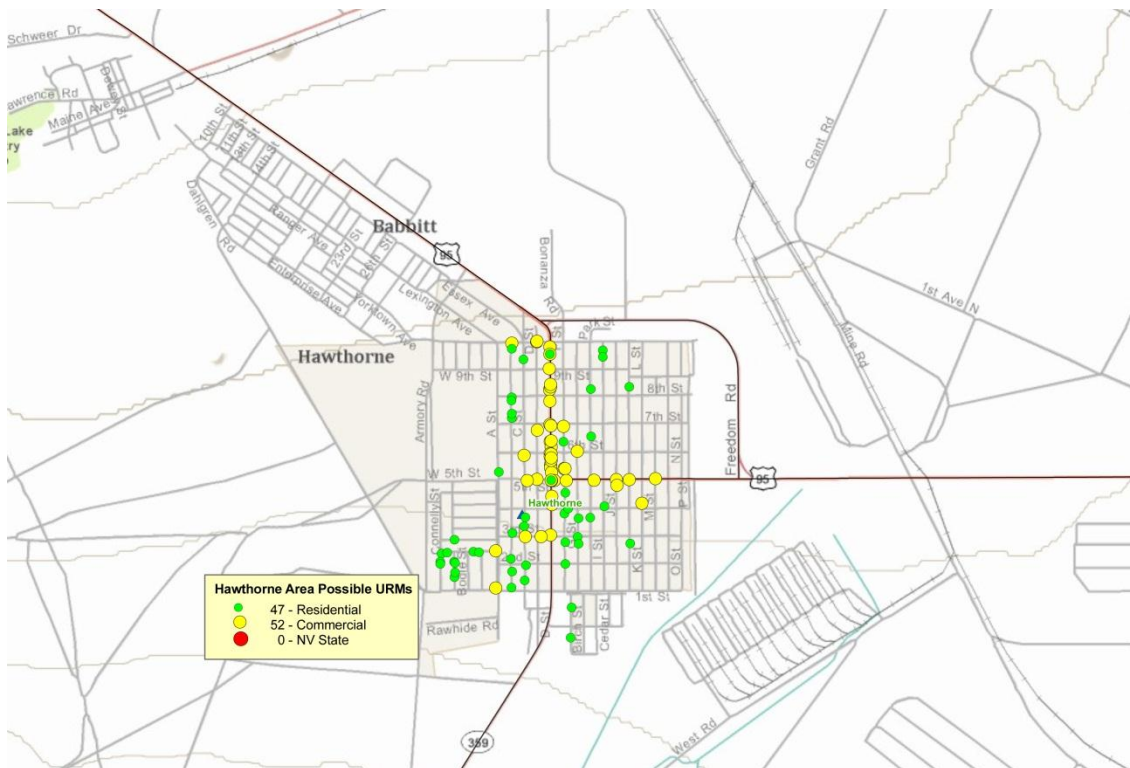


Figure 35. Potential URMs in the Hawthorne area. Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow. The base map is a U.S. Geological Survey topographic map.

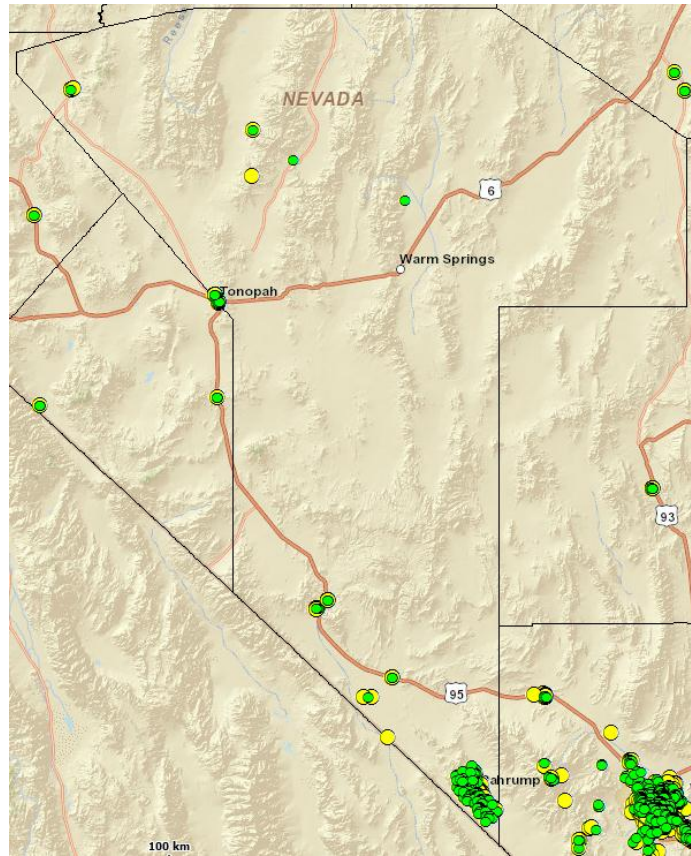


Figure 36. Potential URMs in Nye County (372 total). Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow.

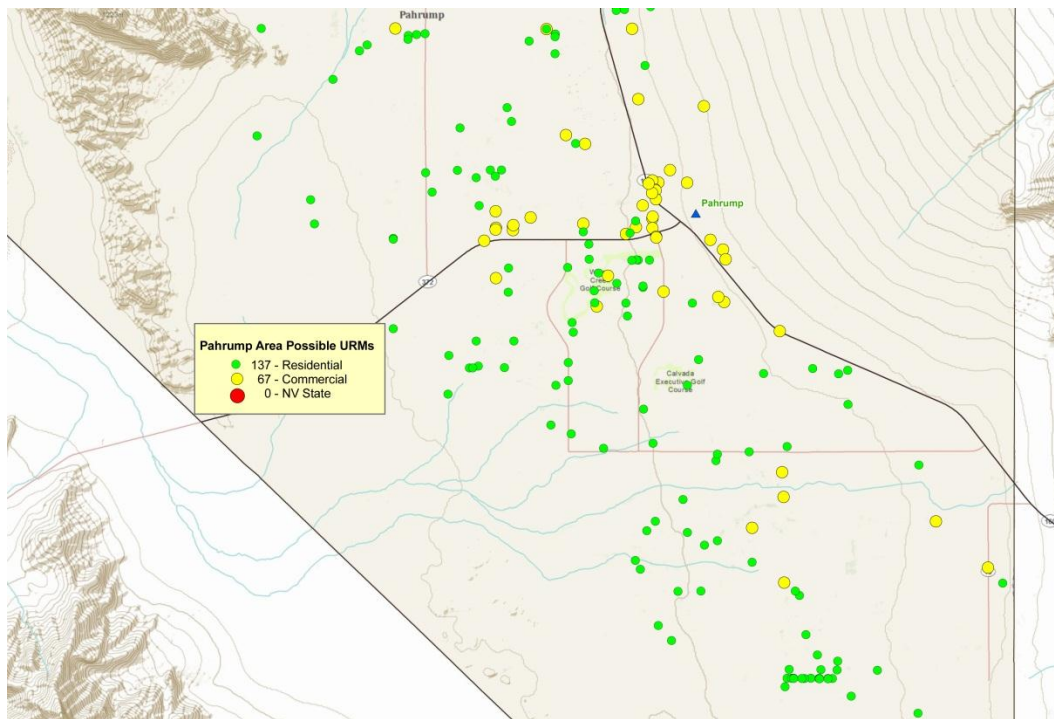


Figure 37. Potential URMs in the Pahrump area. Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow. The base map is a U.S. Geological Survey topographic map.

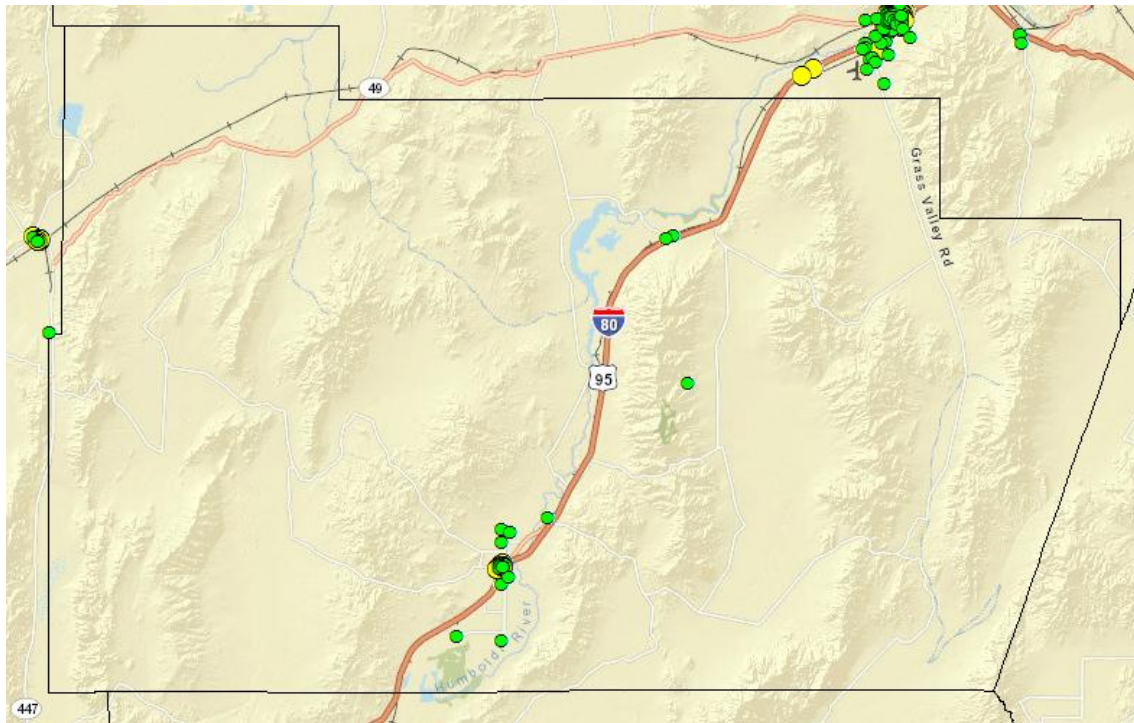


Figure 38. Potential URM in Pershing County (68 total). Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow.

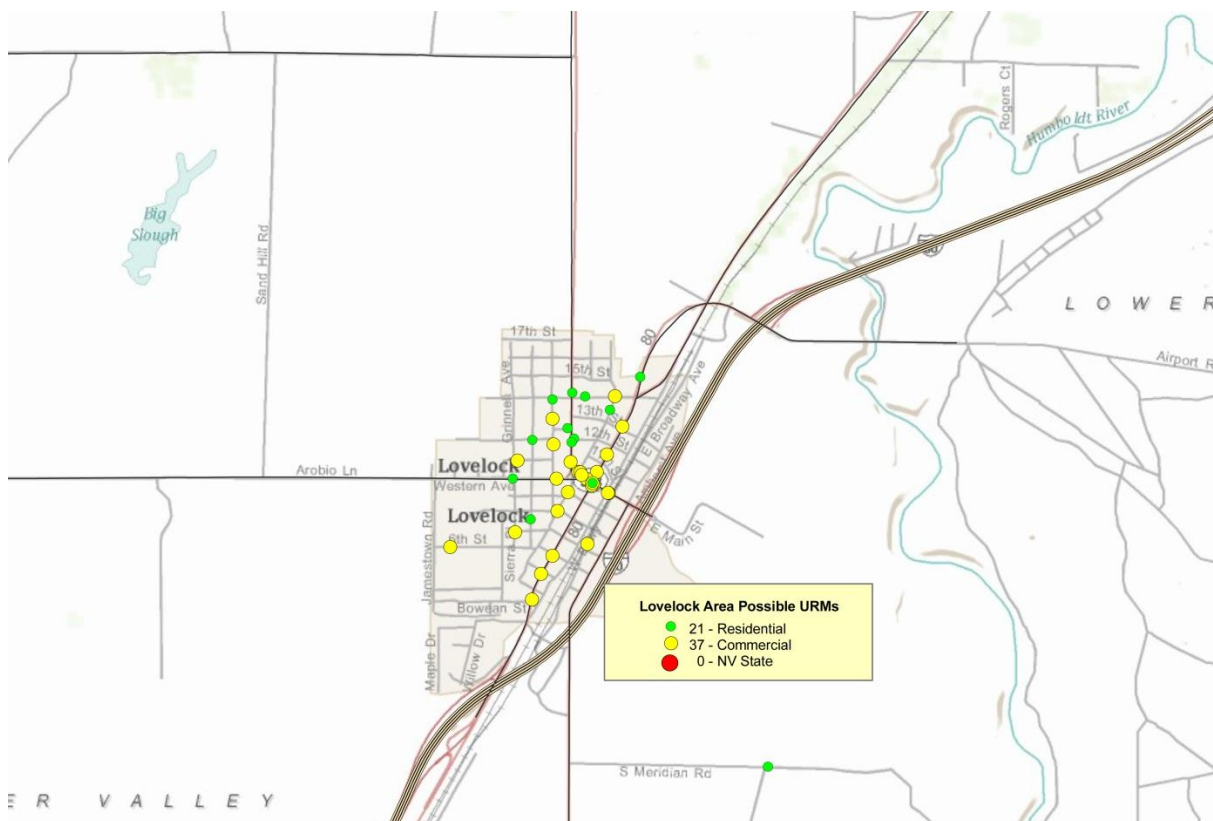


Figure 39. Potential URM in the Lovelock area. Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow. The base map is a U.S. Geological Survey topographic map.

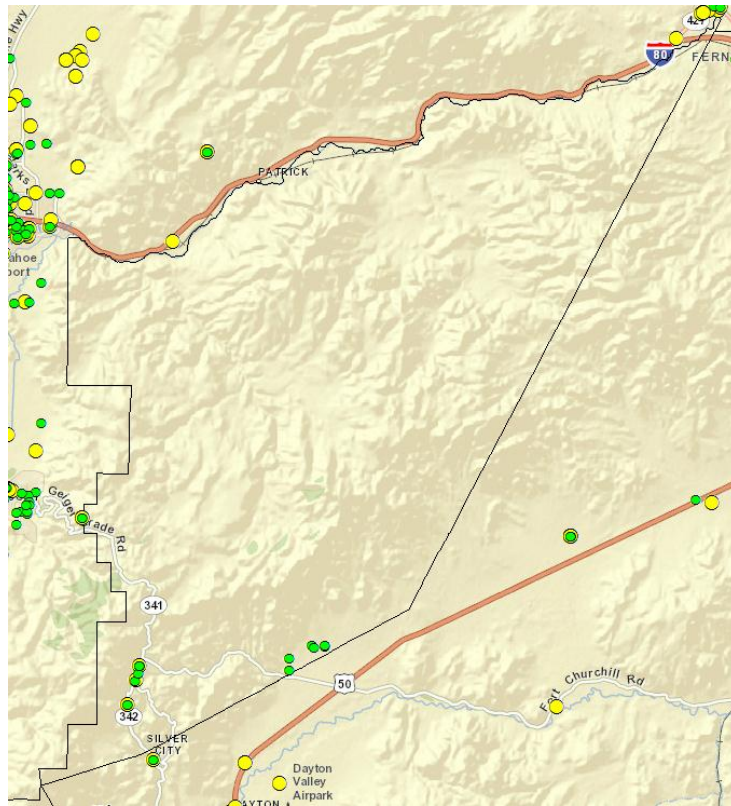


Figure 40. Some of the potential URMs in Storey County (24 total). Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow.

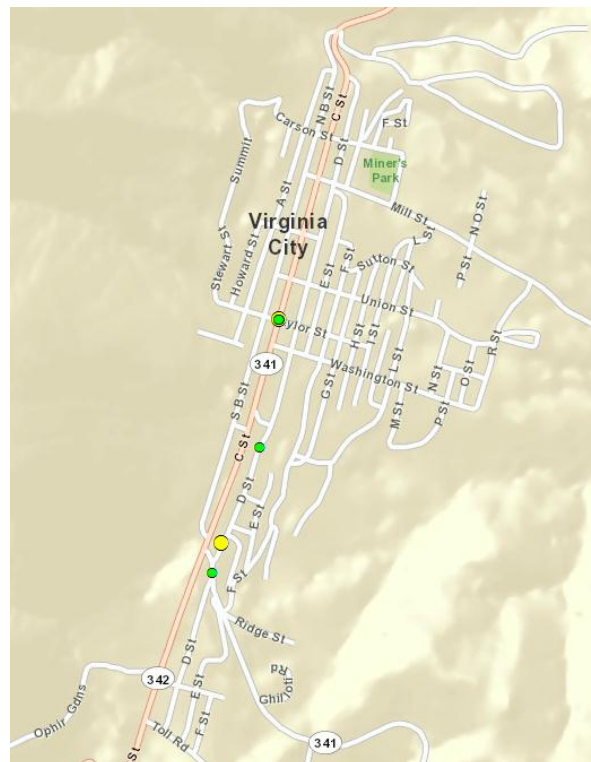


Figure 41. Some of the potential URMs in Virginia City. Residential buildings are plotted in green; commercial buildings are plotted in yellow. Note that green is plotted over and masks yellow.

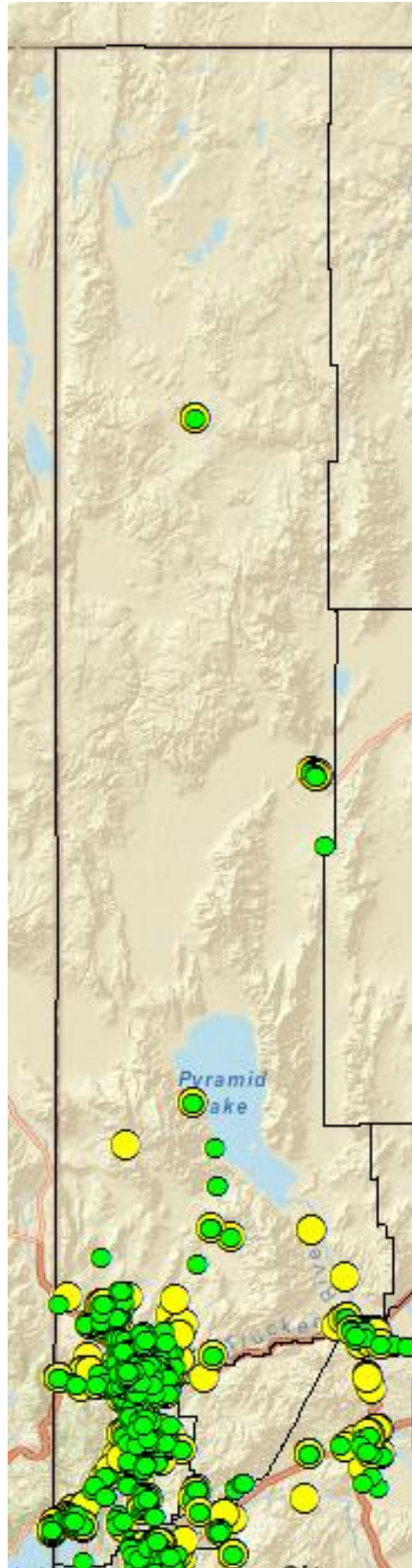


Figure 42. Potential URMs in Washoe County (5,788 total). Residential buildings are plotted in green; commercial buildings are plotted in yellow; State-owned buildings are plotted in red. Note that yellow is plotted over and masks red, and green is plotted over and masks yellow.

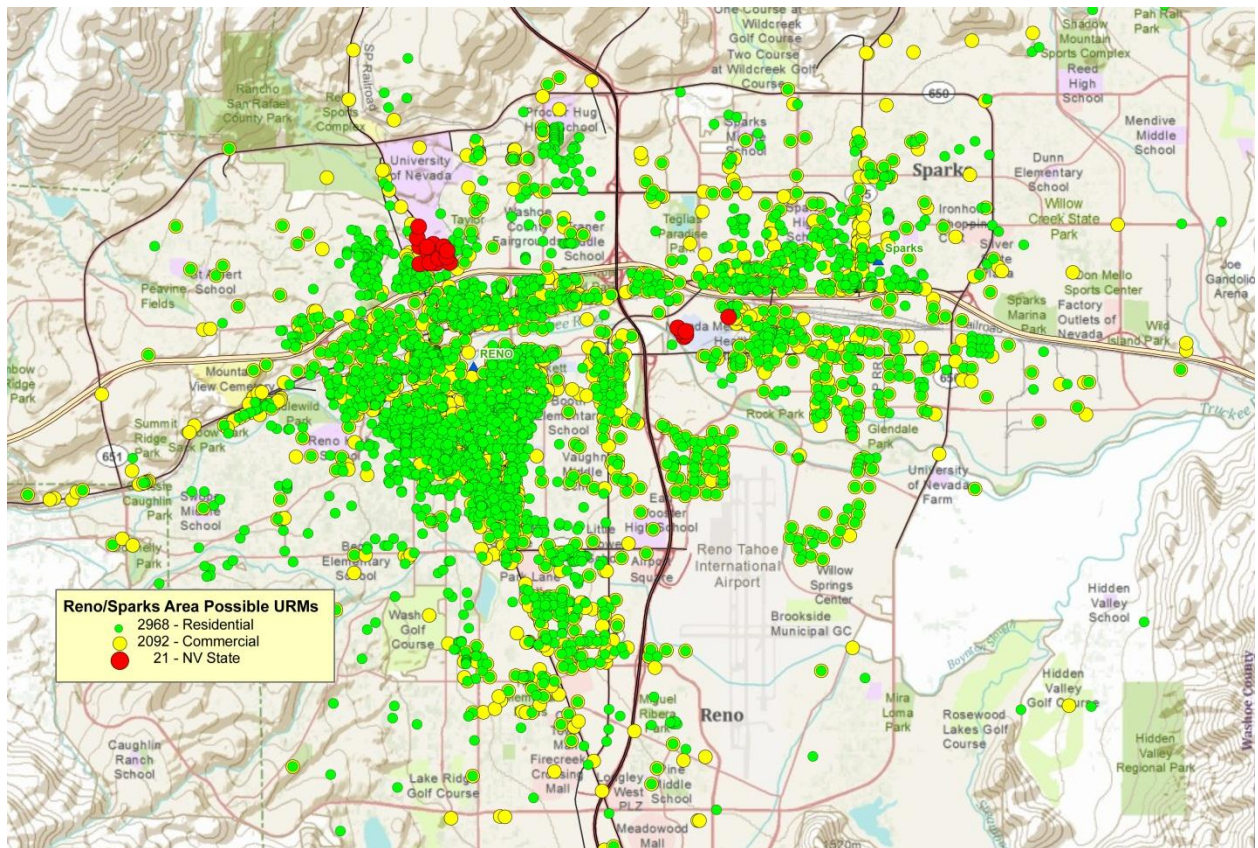


Figure 43. Potential URMs in the Reno-Sparks area. Residential buildings are plotted in green; commercial buildings are plotted in yellow; State-owned buildings are plotted in red. Note that green is plotted over and masks yellow, and red is plotted over and masks both green and yellow. The base map is a U.S. Geological Survey topographic map.

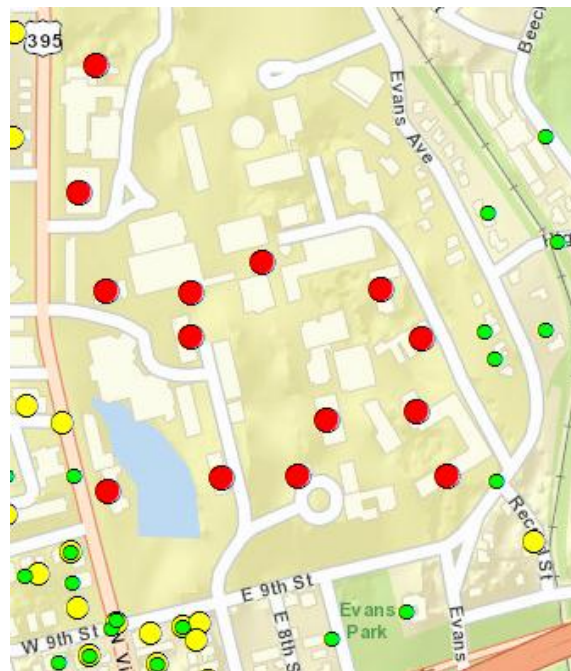


Figure 44. Potential URMs on the University of Nevada, Reno campus. Residential buildings are plotted in green; commercial buildings are plotted in yellow; State-owned buildings are plotted in red. Note that green is plotted over and masks yellow.

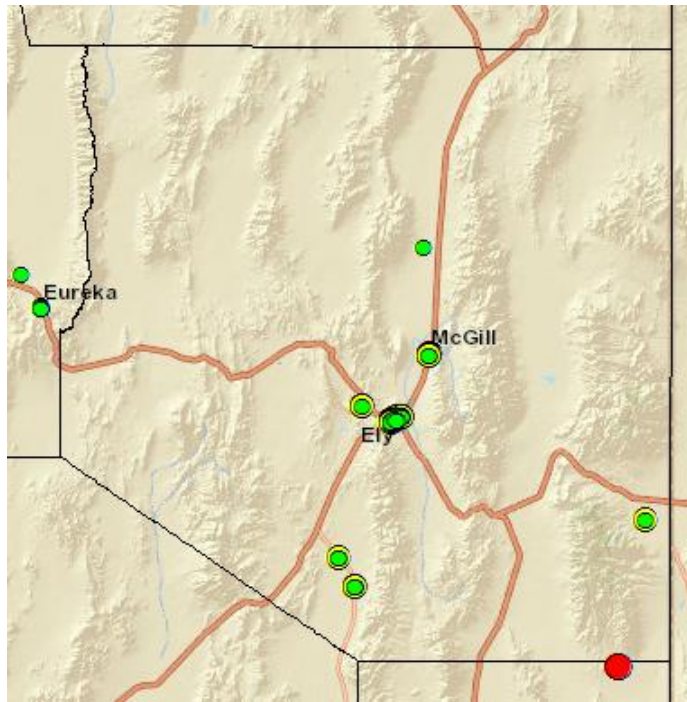


Figure 45. Potential URMs in White Pine County (232 total). Residential buildings are plotted in green; commercial buildings are plotted in yellow; State-owned buildings are plotted in red. Note that yellow is plotted over and masks red, and green is plotted over and masks yellow.

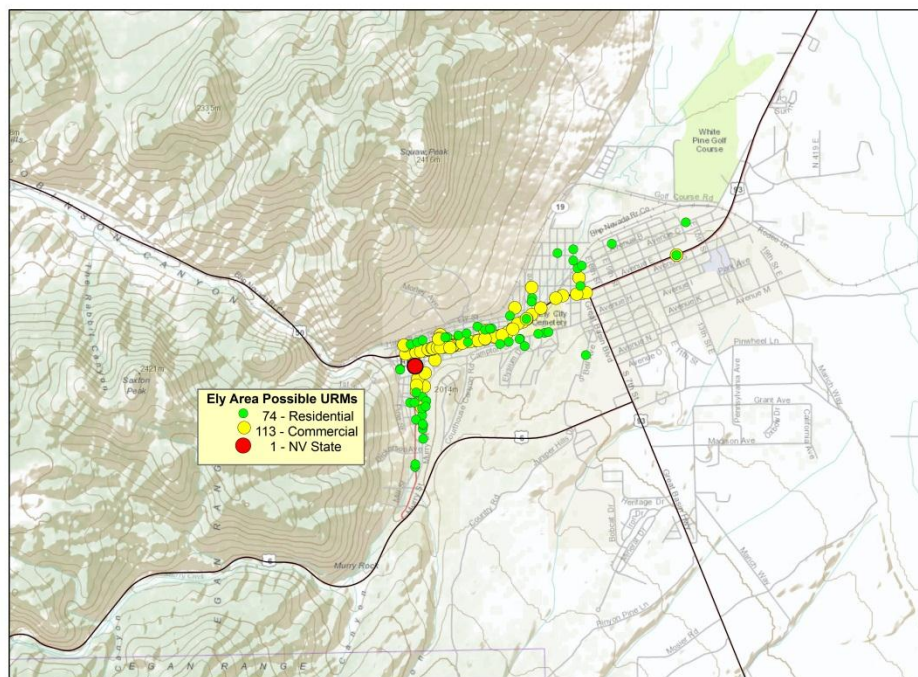


Figure 46. Potential URMs in the Ely area. Residential buildings are plotted in green; commercial buildings are plotted in yellow; State-owned building are plotted in red. Note that green is plotted over and masks yellow, and red is plotted over and masks both green and yellow. The base map is a U.S. Geological Survey topographic map.

Discussion

Many of the potential URMs identified in this assessment are historical buildings (figures 47 through 57). Many are concentrated in downtown business districts and along thoroughfares. Experience from recent earthquakes demonstrates that collapse of these buildings or their facades not only can cause deaths and injuries but also disrupt emergency vehicles during earthquake response and slow business recovery in the weeks and months after the earthquake.



Figure 47. Historical stone cabin, built in the 1870s with blocks of tuff from nearby outcrops, Spring Valley State Park, Lincoln County. Potential injuries to people are minimized by preventing visitors from going inside. Photos by J.G. Price.



Figure 48. A three-story URM in Nevada that has an unanchored parapet and a concrete crowning bond beam along the top. The man in the wheelchair would be challenged to get out of danger during strong ground motion from an earthquake. Photo by C.M. dePolo.



Figure 49. Close up of the parapet and brick construction from the building shown in figure 48. Photo by C.M. dePolo.



Figure 50. Close up of the parapet and brick construction from the building shown in figures 48 and 49. Note the extra bricks and weight in the parapet to give it some ornamentation. Photo by C.M. dePolo.



Figure 51. Cracks around the windows in the building in figure 48. Such cracks resemble the “X” fractures commonly created by earthquake shaking. Photo by C.M. dePolo.



Figure 52. Four story URM in Nevada. Small cracks between the windows indicate this building was probably shaken by an earthquake. Photo by C.M. dePolo.



Figure 53. This tall chimney is an example of other nonstructural parts of URMs that are vulnerable to earthquake shaking. Common failure of URM chimneys is to disintegrate or to break at the roofline and topple. This house also appears to have a rubble-wall foundation, which can be a weakness during earthquake shaking. Photo by C.M. dePolo.



Figure 54. Seismically rehabilitated URM cathedral. For valuable historical buildings, strategies such as interior strengthening and tying the walls and ceilings together can give a URM seismic resistance, which is especially important in high occupancy buildings. Photo by C.M. dePolo.

Blakely and others (2005) conducted a preliminary screening of buildings on the University of Nevada, Reno (UNR) campus in terms of structural integrity during earthquakes. They used a zero-to-seven scoring procedure recommended by the Federal Emergency Management Agency (2002). Blakely and others (2005) recommended that UNR create a seismic upgrade program for each building with a score of 1.0 or less. Ten such buildings were identified in their screening, including URM buildings and buildings with ordinary concrete frames with URM infill walls (table 3).

Table 3. URM buildings (URM) and buildings with ordinary concrete frames with URM-infill walls (OCF-URM) on the University of Nevada, Reno campus.¹

Name	Year built	Structural system	Score (on a scale from 0 to 7)
Manzanita Hall	1896	URM	0.4
Clark Administration	1926	URM	0.5
Palmer Engineering	1941	OCF-URM	0.5
Virginia Street Gym	1943	URM	0.56
Lincoln Hall	1896	URM	0.8
Morrill Hall Alumni Center	1886	URM	1.0
Facilities Service Building	1907	URM	1.0
Jones Center	1913	URM	1.0
Thompson Building	1920	URM	1.0
Mackay Science	1930	OCF-URM	1.0

¹ The State's list of potential URMs has these ten buildings plus the Sarah Fleischmann Building (built in 1957, score=1.36), Fleischmann Agriculture (built in 1957, score=1.36), Getchell Library (built in 1962; score=1.36), and Church Fine Arts (built in 1962, score=1.2). In addition, the Mackay School of Mines Building (built in 1907, score=2.88) and Frandsen Humanities (built in 1917, score=2) were two URM buildings that have had upgrades, which increased their life safety during earthquakes.



Figure 55. Manzanita Hall on the University of Nevada, Reno campus, built in 1896, is a residence hall that houses approximately 97 students. Photo by J.G. Price.



Figure 56. The Clark Administration building on the University of Nevada, Reno campus, built in 1926, includes the offices of the President, Provost, and other administrators. Photo by J.G. Price.



Figure 57. Lincoln Hall on the University of Nevada, Reno campus, built in 1896, houses approximately 73 students. Photos by J.G. Price.

Conclusions and Recommendations

There are tens of thousands of potential URMs in Nevada. They are located in every county and nearly every community. Many URMs are historically significant, and many are concentrated in downtown business districts and along thoroughfares.

URMs are a dangerous risk to occupants and passersby. It is definitely unsafe for occupants to try to run outside of a URM or other building during an earthquake (that is, they should DROP, COVER, and HOLD ON inside the building). The risk from URMs can be mitigated by (a) tearing down the building or (b) rehabilitating the structure (FEMA, 2009). The risk can be lessened by changing occupancy, that is, removing people from the building; by strengthening or removing obvious threats such as facades and parapets that can fall on passersby; and by making sure that there is a relatively safe spot, such as a sturdy table, in every room. When possible, tearing down the building generally is the safest alternative, because even retrofitted URMs may only protect against death from a failing structure. FEMA (2009) provides guidance on how to reduce earthquake risks from URMs.

Major recommendations of this report include:

- (1) Jurisdictions (cities, counties, the State of Nevada, tribes, and the federal government) should follow up with on-the-ground inspections and checks of building plans. A reconnaissance survey in the field, called a rapid visual screening, would be the next step for identifying public URMs within the jurisdictions. Individuals should determine if their buildings are URMs. Everyone should recognize that some URMs are missing from the database and that some building listed as potential URMs are actually adequately reinforced.
- (2) Jurisdictions should work toward seismically rehabilitating URMs or removing them from human occupancy. They can take advantage of opportunities for federal funding for mitigation. They can learn from what other jurisdictions have done successfully, such as providing incentives for individuals and businesses to rehabilitate URMs or replace them with new buildings. Buildings should be brought up to current code during remodeling.

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Disclaimer

The information in this report should be considered preliminary. As stated in the first recommendation, follow-up work is necessary to determine whether the potential URMs are indeed URMs and to add other URMs that are missing

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