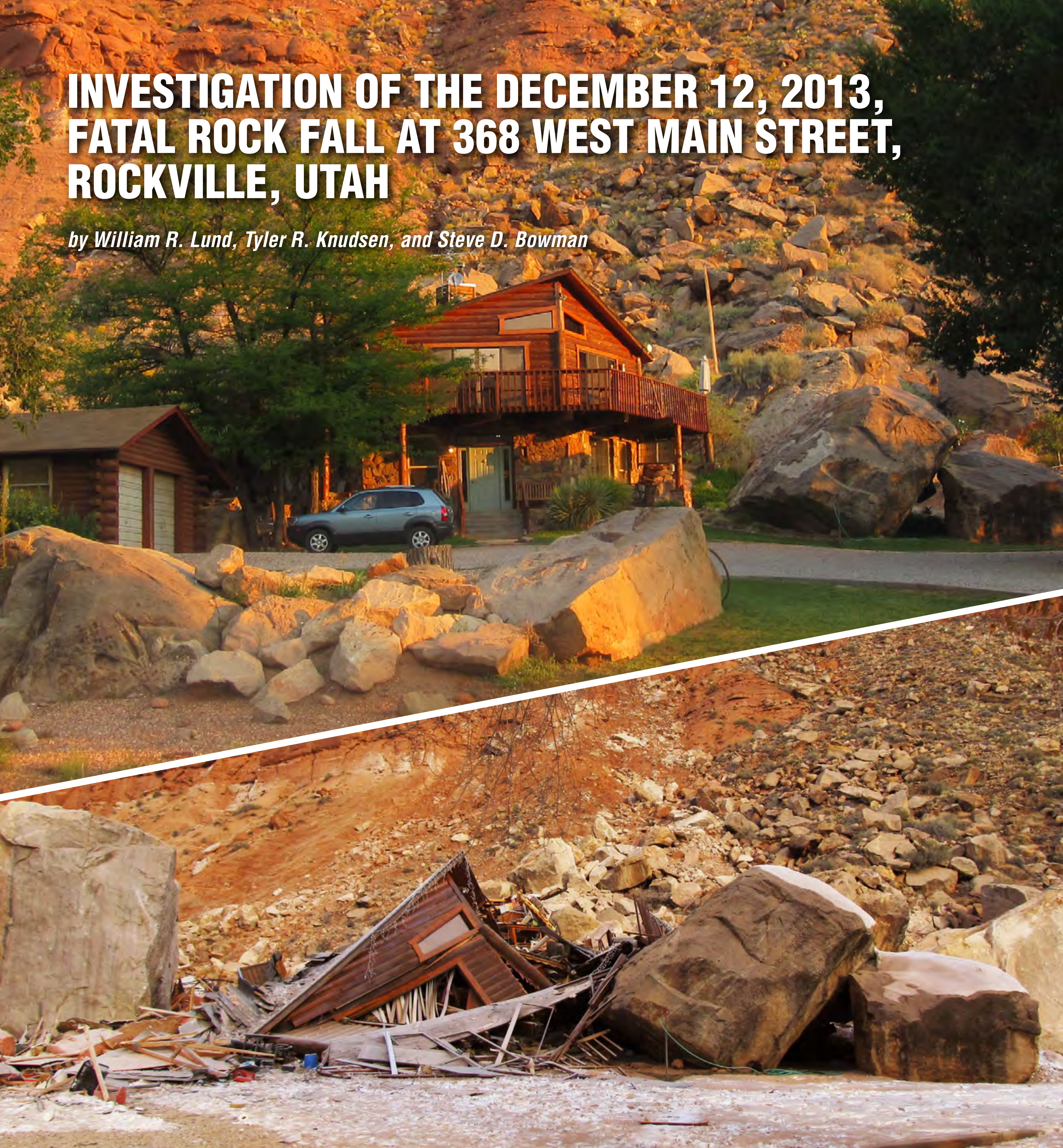

INVESTIGATION OF THE DECEMBER 12, 2013, FATAL ROCK FALL AT 368 WEST MAIN STREET, ROCKVILLE, UTAH

by William R. Lund, Tyler R. Knudsen, and Steve D. Bowman

UTAH DNR GEOLOGICAL SURVEY

REPORT OF INVESTIGATION 273
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2014

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Cover photo: Before and after views of the property at 368 West Main Street in Rockville, Utah, showing the house destroyed by the December 12, 2013, rock fall.

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CONTENTS

FIGURES

INVESTIGATION OF THE DECEMBER 12, 2013, FATAL ROCK FALL AT 368 WEST MAIN STREET, ROCKVILLE, UTAH

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ABSTRACT

On December 12, 2013, a large rock mass (estimated 2700 tons) detached from the Shinarump Conglomerate cliff capping the Rockville Bench above Rockville, Utah, and fell onto a steep slope (average 35 degrees) below the cliff, where it shattered into numerous cobble- to boulder-sized fragments, some weighing multiple hundreds of tons. The rock-fall debris then rolled and bounced downslope at a high rate of speed, where some debris collided with large, previously fallen boulders at the base of the slope and shattered into hundreds of additional fragments. Numerous large boulders continued beyond the base of the slope (likely including fragments shattered from the previously fallen boulders), several of which struck and destroyed a house, a two-car detached garage, and a car parked in the garage driveway at 368 West Main Street. The two occupants in the house were killed. The purpose of this investigation is to document the characteristics of the fatal December 12, 2013, rock fall; evaluate future rock-fall hazard potential at the site; and provide recommendations for homeowners, the Town of Rockville, and other officials to consider in managing rock-fall risk.

Our investigation showed that a second, partially detached rock mass, potentially as large or larger than the first, is present at the cliff face above the site, and that the rock-fall hazard remains very high for the site and adjacent properties. This information was communicated to Springdale/Rockville Chief of Police Kurt Wright, who accompanied us on a helicopter and foot reconnaissance of the cliff, and was subsequently provided to the Rockville mayor and mayor-elect.

The cliff from which the rock fall initiated is approximately 375 feet above the valley floor, and the boulders that destroyed the house traveled approximately 750 feet (slope distance; 530 feet map [horizontal] distance) before striking the structure. The two largest boulders to reach the site weighed an estimated 490 and 520 tons, respectively, and several other boulders are estimated to weigh well in excess of 20 tons. The farthest travelled rock-fall debris consisted of two comparatively small boulders on the south side of Main Street/State Route 9 approximately 895 horizontal feet (map distance) from the cliff where the rock fall initiated, and about 350 feet from where the rock-fall boulders collided with the boulders at the base of the slope.

A rock-fall-hazard map, prepared by the Utah Geological Survey in 2011, shows that the structures destroyed by the December 12th rock fall were within a mapped high rock-fall-hazard area. The map also shows that a high rock-fall hazard exists at the base of the Rockville Bench throughout the Town of Rockville, and encompasses many residences and other structures. Residents within the high-hazard zone face the possible consequences of a large rock fall similar to the one at 368 West Main Street.

Geotechnical engineers from the Utah Department of Transportation (UDOT) evaluated the site, and concluded that the large size and high energy of the boulders generated from the Rockville Bench makes rock-fall mitigation neither practical nor cost effective. Based on similarities between the December 12th rock-fall site and other locations at the base of the Rockville Bench in western Rockville, particularly the lack of sufficient space to construct rock-fall-risk-reduction structures, rock-fall mitigation is likely neither practical nor cost effective in those areas as well. Therefore, residents within high rock-fall-hazard areas of western Rockville have two options: (1) accept the hazard and continue to live in the high-hazard area knowing that the consequences of that decision could result in significant property damage and may prove fatal, or (2) relocate from high-hazard areas. Residents at the base of the Rockville Bench farther east in Rockville may, in some instances, have a third option where sufficient space is available to construct rock-fall-risk-reduction structures. Whether or not such measures are possible at a particular location would require detailed hazard and engineering investigations. It is the responsibility of the Town of Rockville to ensure that current and prospective future residents and land owners within high rock-fall-hazard areas are made fully aware of the hazard, so they can make an informed decision regarding their future course of action regarding rock-fall hazard. It is unknown if federal, state, or other funds are available to permit the Town of Rockville to either purchase the properties of homeowners who wish to relocate from the high-hazard areas, or to move houses to safe locations outside of the hazard areas. We recommend that the Town of Rockville investigate the feasibility of taking such action.

INTRODUCTION

At approximately 5:00 p.m. on December 12, 2013, a large, joint-controlled rock mass detached from a cliff formed by the Shinarump Conglomerate Member of the Chinle Formation at the top of the Rockville Bench above Rockville, Utah (figure 1). The rock mass fell onto a steep slope formed by the upper red and Shnabkaib Members of the Moenkopi Formation and shattered into numerous cobble- to boulder-sized fragments (the largest weighing multiple hundreds of tons), which then rolled and bounced downslope at

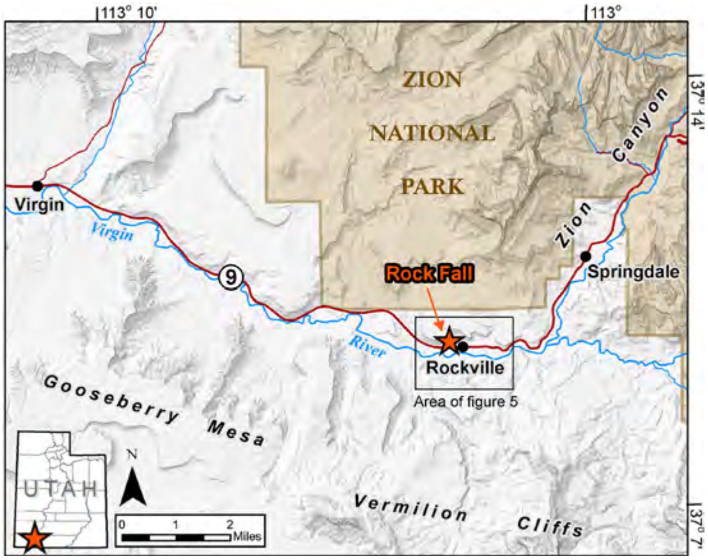

Figure 1. *Location of the Town of Rockville and the December 12, 2013, fatal rock fall; shaded relief base map generated from the U.S. Geological Survey National Elevation Dataset (NED).*

a high rate of speed. Some of the fast-moving rock-fall debris collided with large, previously fallen boulders at the base of the slope and shattered into hundreds of additional fragments. Several large boulders continued beyond the base of the slope (possibly including shattered fragments of the previously fallen boulders) and destroyed a house, garage, and car at 368 West Main Street in Rockville (figures 2, 3, and 4). The two occupants in the house were killed.

Purpose and Scope

The purpose of this investigation is to document the December 12, 2013, fatal rock fall at 368 West Main Street (State Route 9 [SR-9]) in Rockville, Utah. This report summarizes our observations and conclusions, discusses future rock-fall hazard potential at the site, and provides recommendations for homeowners, the Town of Rockville, and other officials to consider in managing rock-fall risk. We focus here on rock-fall susceptibility of rock outcrops and talus above the site; however, Rockville is the location of several past damaging rock falls (e.g., Lund, 2002; Knudsen, 2011; Knudsen and Lund, 2013) (figure 5), and Utah Geological Survey (UGS) Report of Investigation 270 (Knudsen, 2011) provides a broader discussion of rock-fall hazard in Rockville. An unpublished UGS contract deliverable report, *Geologic-Hazard Investigation State Route 9 Corridor, La Verkin City to Town of Springdale, Washington County, Utah* (Knudsen and Lund, 2011), included a suite of geologic-hazard maps that were provided to the Town of Rockville at a December 2011 public meeting hosted by the Town of Springdale. The suite of maps included a rock-fall-hazard map that identified and ranked rock-fall-hazard areas in the Town of Rockville. Note that the SR-9 geologic hazard corridor investigation is now published as UGS Special Study 148 (Knudsen and Lund, 2013).

Two geologists (Lund and Knudsen) from the UGS Southern Utah Regional Office in Cedar City responded to the rock fall on the morning of December 13, 2013. They contacted Kurt Wright, Springdale/Rockville Chief of Police, and then made a preliminary investigation of the rock fall. Later, they accompanied Chief Wright on a helicopter and foot reconnaissance of the cliff above the site from which the rock mass detached, and after an inspection, advised Chief Wright that a second, partially detached rock mass as large or larger than the first, was present at the cliff face and represented an ongoing danger to responders, other structures, and residents at the base of the Rockville Bench. Lund and Knudsen made a second site visit on December 17, 2013, with Steve Bowman, UGS Geologic Hazards Program Manager, to further investigate the rock fall and obtain measurements of several large boulders for volume and mass (weight) estimates (see below).

Sources of Information

In addition to the two site visits, we reviewed relevant geologic maps, literature, and aerial photography including UGS Open-File Report 394, *Interim Geologic Map of the Springdale West Quadrangle, Washington County, Utah* (Willis and others, 2002); UGS Report of Investigation 270, *Investigation of the February 10, 2010, Rock Fall at 274 West Main Street, and Preliminary Assessment of Rock-Fall Hazard, Rockville, Washington County, Utah* (Knudsen, 2011), which documents several previous Rockville rock falls; UGS contract deliverable report, *Geologic-Hazard Investigation State Route 9 Corridor, La Verkin City to Town of Springdale, Washington County, Utah* (Knudsen and Lund, 2011; subsequently published as UGS Special Study 148), which includes a rock-fall-hazard map that covers the Town of Rockville; 2006 high-resolution orthophotography (HRO; Utah Automated Geographic Reference Center, 2006); 2009 (Utah Automated Geographic Reference Center, 2009) and 2011 (Utah Automated Geographic Reference Center, 2011) National Agriculture Imagery Program (NAIP) orthophotography at various scales; and undated oblique aerial photos acquired by Pictometry International and viewed using Microsoft's Bing Maps software (http://www.bing.com/maps/).

ROCK-FALL DESCRIPTION AND SIZE ESTIMATES

Rock-Fall Description

The rock mass that sourced the December 12, 2013, fatal rock fall detached from a vertical cliff formed by the Shinarump Conglomerate Member of the Chinle Formation at the top of the Rockville Bench (figure 6). The Shinarump outcrop is approximately 375 feet above the adjacent valley floor. Upon impact with the steep (average 35 degrees) slope formed on the upper red and Shnabkaib Members of the Moenkopi Formation at the cliff base, the rock mass shattered into numerous cobble- to boulder-sized fragments (the largest weighing multiple hundreds

Figure 2. *View of the property at 368 West Main Street in Rockville, Utah, taken on September 29, 2010. The house, garage, and car were subsequently destroyed by a rock fall on December 12, 2013; note large pre-existing rock-fall boulders within the property; view is to the north.*

Figure 3. *Remains of the house at 368 West Main Street, Rockville, Utah, following the December 12, 2013, rock fall. Photograph taken December 13, 2013, view is to the north.*

Figure 4. *Detached two-car garage and car at 368 West Main Street, Rockville, Utah, destroyed by the December 12, 2013, rock fall. Photograph taken on December 13, 2013, view is to the northwest.*

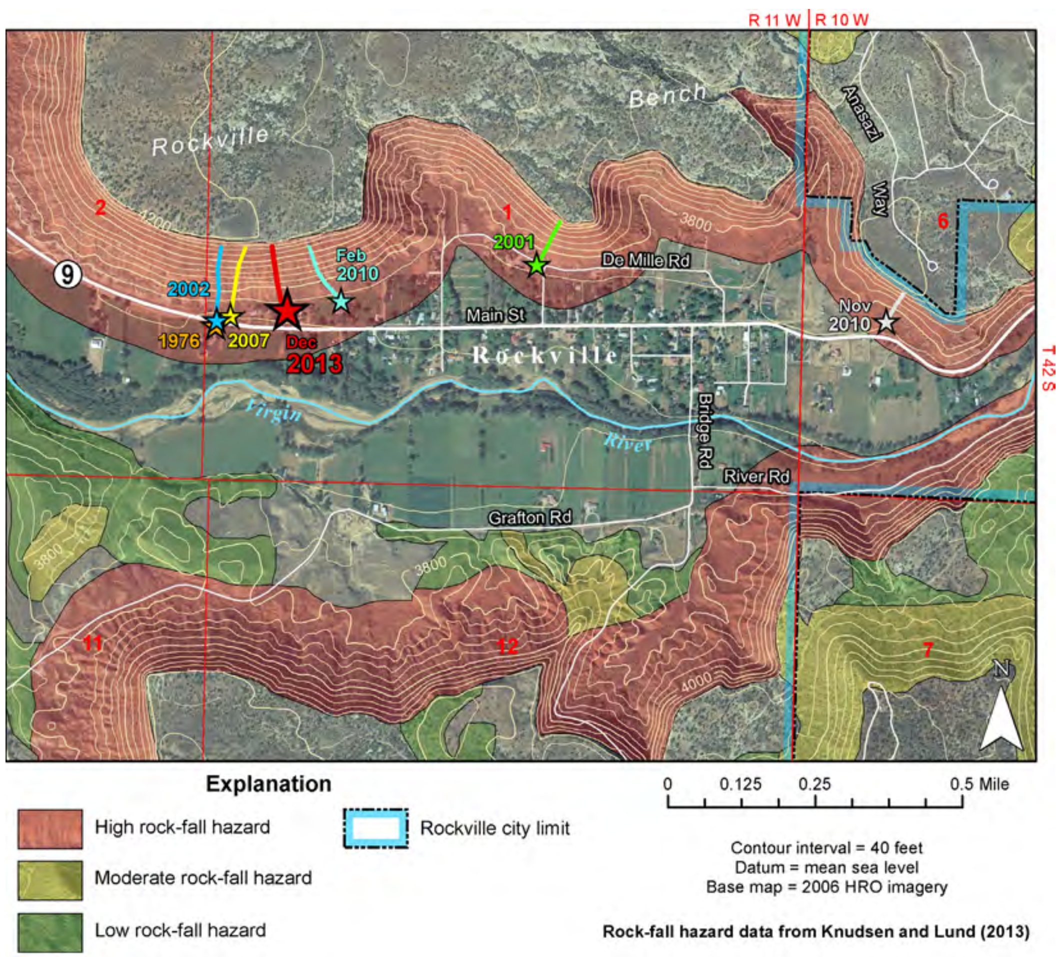

Figure 5. *Rock-fall hazard zones and significant historical rock falls (stars) and their travel paths (bold colored lines) in the Town of Rockville. Modified from Knudsen (2011).*

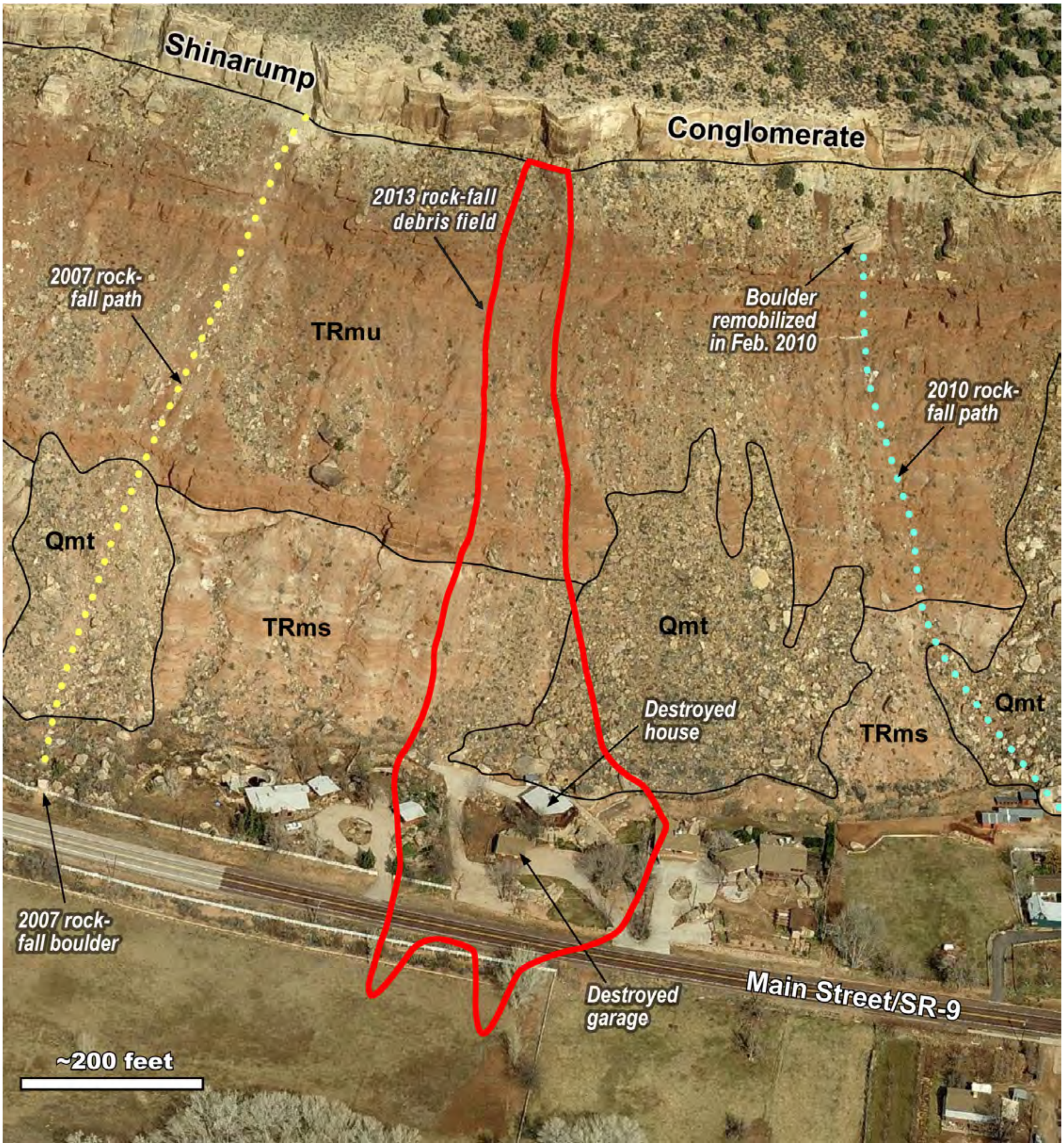

Figure 6. *North-directed, circa-2008, oblique aerial view of Rockville Bench showing maximum extent of debris field of the December 12, 2013, rock fall (red line); house destroyed by the December 12, 2013, rock fall; other recent Rockville rock falls in the vicinity; and major geologic units—TRmu=upper red member of the Moenkopi Formation, TRms=Shnabkaib Member of the Moenkopi Formation, Qmt=talus (rock fall) deposits. Photo from Microsoft Bing Maps (http://www.bing.com.maps/).*

Figure 7. After falling onto the Moenkopi slope, the rock mass broke into hundreds of individual fragments ranging from cobble-size material to multiple-hundred ton boulders as it moved downslope. Photograph taken on December 13, 2013, view is to the south.

of tons, see below), which rolled and bounced rapidly down the slope (figure 7). The owner of the house immediately west of the rock-fall site was home at the time of the event, and estimated that as few as 5 seconds elapsed between hearing a sharp cracking noise that likely signaled the rock mass detaching from the cliff, and the time when boulders struck the house next door. A passing motorist photographed the dust cloud resulting from the rock fall (figure 8), and estimated the fall occurred in 10 seconds or less.

The rock-fall path was partially influenced by the presence of small, pre-existing gullies on the Moenkopi slope (figure 9), and was delineated by churned soil and vegetation, fresh rock deposition, both soil and rock gouge, and impact craters (figure 10). Some of the rapidly moving rock-fall debris collided with large, previously fallen boulders at the base of the slope (figures 2 and 6) and shattered into hundreds of additional fragments. Numerous large boulders continued beyond the base of the slope (likely including fragments shattered from the previously fallen boulders), several of which struck and destroyed a house, a two-car detached garage, and a car parked in the garage driveway at 368 West Main Street.

The rock-fall boulders traveled an estimated 750 feet (slope distance; 530 feet horizontal [map] distance) before striking the house. Debris continued tens of feet past the house to impact the garage and car. Rock-fall debris traveling a similar distance encroached on the property immediately to the west, where one small rock fragment slightly damaged the roof of a detached garage, and a boulder, estimated as less than a cubic yard in size, destroyed a small utility trailer (figure 11). The farthest traveled rock-fall debris consisted of two comparatively small boulders, the larger one having an estimated volume of 19 ft^3 and weight of 2700 pounds, which bounced entirely across Main Street/SR-9 (no gouge marks in the road pavement, shoulder, or embankment) and came to rest in a pasture south of the road (figure 12). The two boulders were approximately 895 horizontal feet (map distance) from the cliff face that sourced the rock fall. However, it is possible that the two boulders were fragments shattered from pre-existing boulders at the base of the slope, in which case, the distance traveled would be approximately 350 feet. The shadow angle from the farthest debris measured back to the base of the Shinarump cliff was 24°, which is within the high rock-fall-hazard area defined by the 22° shadow angle used by Knudsen and Lund (2011, 2013) to construct the rock-fall-hazard map for the SR-9 corridor that includes the Town of Rockville. The shadow angle is

Figure 8. *Dust cloud resulting from the December 12, 2013, rock fall in Rockville, Utah. The motorist who witnessed the event estimated that the duration of the rock fall was 10 seconds or less. Photograph taken by Jack Seegmiller on December 12, 2013, view is to the west.*

Figure 9. *Upper part of the path taken by the December 12, 2013, rock fall. Note how pre-existing small gullies on the Moenkopi slope split and redirected a portion of the rock fall. Numerous freshly fallen boulders of unknown stability remain on the slope along the rock-fall path. Photograph taken on December 13, 2013, view is to the northwest.*

Figure 10. *Example of an impact crater, gouge, and vegetative debris created by a rolling/bouncing boulder during the December 12, 2013, rock fall. Photograph taken on December 13, 2013, view is to the south.*

the average angle of an imaginary line extending from the bottom of a rock-fall source (in this case, the Shinarump Conglomerate) to the rock's final resting place (figure 13). Lund and others (2010) and Knudsen (2011) measured dozens of the farthest outlying boulders of rock-fall deposits in Zion National Park and Rockville, respectively, and concluded that a 22° shadow angle is a reasonable value for estimating maximum rock-fall runout distance in the Zion Canyon area.

No specific triggering event is known for the rock fall. However, for the month preceding the event (November 12 to December 12) total precipitation recorded at the nearest weather station (ZION NP) in nearby Zion National Park was 1.59 inches (Utah Climate Center, 2014). For the eight days prior to the event, minimum temperatures recorded at the same weather station were consistently below 22°F, and the lowest temperature was -4°F on December 9 (Utah Climate Center, 2014). The ground was covered with snow and ice at the time of our site visit on December 13. The cold temperatures and abundant moisture may have instigated freeze/thaw cycles between cold nights and warming days that weakened the rock mass to the point of failure.

Rock-Fall Volume and Mass Estimates

We estimated both the volume and mass (weight) of the rock mass that sourced the rock fall and of several of the largest boulders that reached the site. The estimates are based on two assumptions: (1) the rock mass, and the boulders derived from it, approximate regular geometric shapes, which is true to a greater or lesser degree depending on the individual boulders, and (2) the specific gravity of the Shinarump Conglomerate is approximately 2.3. Rock-fall boulders examined during our site visits consisted chiefly of medium- to coarse-grained, well-indurated sandstone with lenses of pebbly sandstone and pebble conglomerate. Given the predominance of sandstone in the composition of the boulders, we used the average of the range of specific gravity values reported for sandstone (2.28–2.37) in the American Geological Institute (AGI) *Geoscience Handbook* (AGI, 2006) for our mass calculations. The average is 2.33, which we round to 2.3 to reflect the fact that the value we used is an estimate, and was not determined specifically for rock at this site. Given the above assumptions regarding the shapes of the rock mass and boulders and their specific gravity, we consider our volume and mass estimates accurate to ± 15%.

Figure 11. *Boulder (A) with an estimated volume less than one cubic yard that destroyed a small utility trailer (B) on the property immediately west of the December 12, 2013, rock-fall location. Photographs taken on December 13, 2013, views are to the south.*

Figure 12. *Largest of two boulders that represent the farthest traveled rock-fall debris from the December 12, 2013, rock fall. The boulder is in a pasture on the south side of Main Street/SR-9 directly across from the rock-fall site (see figure 6). The boulder has an estimated volume of 19 ft³ and weight of 2700 pounds, and is approximately 895 horizontal feet (map distance) from the Shinarump cliff on top of the Rockville Bench that sourced the rock fall. The boulders apparently bounced/flew across Main Street (no gouge marks in road pavement, shoulder, or embankment) and cleared both an above-ground telephone line and the fence in the foreground without damaging either. Note the beginning point of the boulder roll path in the snow. Large photograph taken on December 13, 2013, view is to the southwest. Inset photograph taken on December 17, 2013, view is to the northeast.*

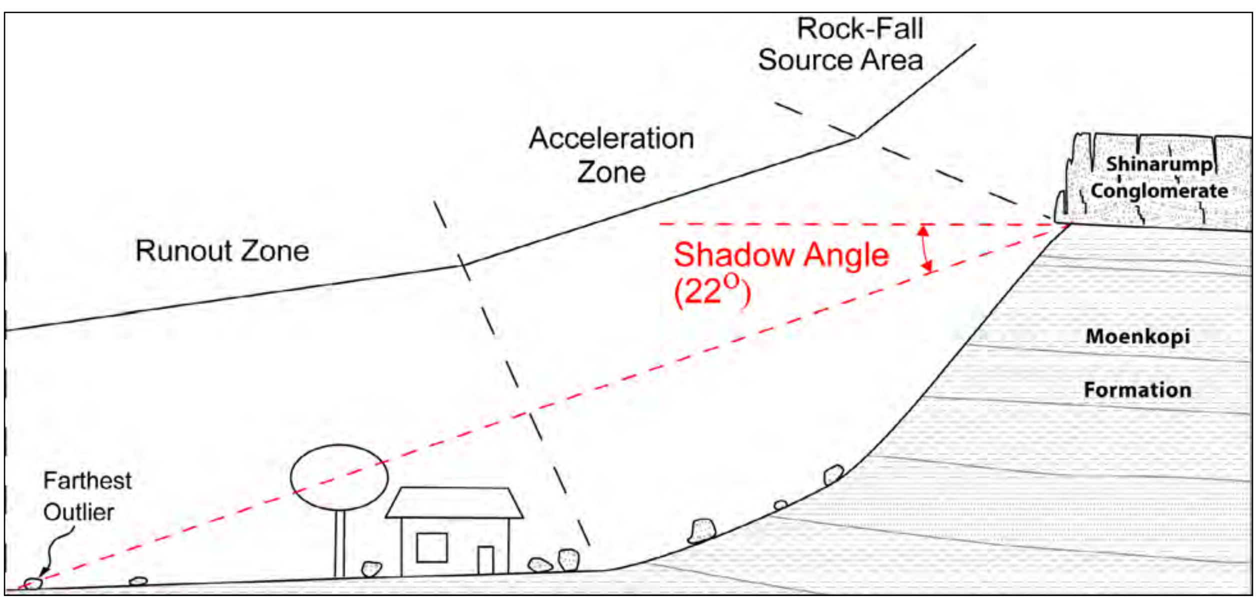

Figure 13. *Components of a characteristic path profile for rock falls sourced from Rockville Bench (modified from Lund and others, 2008).*

Based on aerial-photo analysis, the size of the detachment surface, thickness of the Shinarump Conglomerate Member, and amount of material at the bottom of the slope, we estimate the rock mass was roughly rectangular with dimensions of about 18 x 32 x 65 feet (figure 14) and a volume of approximately 37,000 ft^3 (1400 yd^3); all volume and mass estimates are rounded to two significant figures. Using a specific gravity of 2.3 for the Shinarump Conglomerate, the weight of the rock mass that sourced the rock fall was approximately 2700 tons. The largest rock-fall boulder to reach the site weighed an estimated 520 tons and came to rest within the shattered remains of the house (figure 15). A second, very large boulder with an estimated weight of 490 tons (figure 16) came to rest within several feet of the house to the east. Other large boulders ranging from 20 to likely greater than 100 tons also reached the site. Large boulders mostly buried by the rubble of the house and garage could not be accurately measured for a volume estimate, but the boulder that hit the car in the driveway (figure 17) weighed an estimated 41 tons, as did the largest boulder to reach the property immediately west of the site (figure 18).

The rock fall also generated hundreds of smaller cobble- and boulder-sized fragments (figure 7), far too many to measure individually for a volume/mass estimate of the rock-fall debris that reached the site, and fresh-appearing boulders remained scattered along the rock-fall path on the slope above the site. Additionally, it is not known how much of the fresh rock on site was derived from shattering of the large boulders already present at the base of the slope prior to the December 12th rock fall.

ROCK-FALL POTENTIAL

The well-indurated Shinarump Conglomerate, where it caps slopes of less-resistant Moenkopi Formation, is a well-recognized source of rock falls throughout southwestern Utah (Lund and others, 2008, 2010; Knudsen, 2011; Knudsen and Lund, 2013). Numerous fresh-appearing rock-fall scars on the cliff face and widespread distribution of Shinarump-derived talus at the base of Rockville Bench attest to the frequency and widespread occurrence of past rock falls in Rockville. Knudsen (2011) documented at least five relatively large rock falls within Rockville in the 35 years (four in the past nine years) prior to the December 12th event, all sourced from the Shinarump cliff at the top of the bench. In at least one case, the boulder that eventually came down was initially stranded high on the Moenkopi slope after detaching from the cliff face (figure 6), and its movement subsequently reactivated only after a long period of slope erosion (Knudsen, 2011). The boulder then rolled rapidly to the bottom of the slope, where it also shattered against a large, previously fallen boulder, and fragments from the collision destroyed two outbuildings and damaged a house and car at 274 West Main Street.

Our helicopter and foot reconnaissance of the cliff at the top of the Rockville bench conducted with Chief Wright, showed that a second, large, joint-controlled rock mass is partially detached from the cliff face (figure 19) above the site, and could fall at any time. Additionally, the slope below the cliff is littered with boulders related to both the December 12th and earlier rock falls (figures 6 and 7), all of unknown stability. Elsewhere along the cliff, we observed large, cliff-face-parallel joints, which, although apparently not affected by the December 12th rock fall, can serve as detachment surfaces for subsequent rock falls. We concluded that the rock-fall hazard at and adjacent to this site remains very high, due chiefly to the recentness of the December 12th rock fall and consequent presence of a now partially detached section of the cliff above the site. However, predicting the precise timing of future rock falls is not possible (see Knudsen, 2011), and it is not known when the partially detached rock mass will fall. The rock-fall-hazard map prepared by the UGS for the SR-9 corridor between La Verkin and Springdale (Knudsen and Lund, 2011, 2013) (figure 5) shows a high rock-fall-hazard zone is present all along the base of the Rockville Bench in Rockville. The December 12th rock fall, and the frequency and distribution of past rock falls in Rockville (Knudsen, 2011), amply validate the map's hazard zones. Residents living anywhere within a high rock-fall-hazard zone in Rockville face the possible consequences of a large rock fall similar to the one that occurred at 368 West Main Street (figure 20). For those interested, Knudsen (2011) provides details regarding historical Rockville rock falls, rock-fall-hazard runout distances, and hazard characterization techniques.

CONCLUSIONS AND RECOMMENDATIONS

Town of Rockville Mayor Dan McGuire requested assistance from the Utah Governor's Office to assess the feasibility of mitigating the rock-fall hazard at and near the site of the December 12th event. The UGS had already responded to the event; subsequently, engineers from the Utah Department of Transportation (UDOT) Geotechnical Division visited the site to determine if the rock-fall hazard there can be mitigated. In a letter to Mayor McGuire dated December 23, 2013 (reproduced in the appendix of this report), Keith Brown, UDOT Chief Geotechnical Engineer, stated that "rock-fall mitigation technologies such as rock-fall fences or catchment ditches would be ineffective due to the large size and high energy of the typical boulders involved." Mr. Brown further concluded that "the cost of prevention strategies such as rock bolting the cliff areas would greatly exceed the value of the endangered properties and the effectiveness would be questionable." We concur with the UDOT conclusions.

The UGS rock-fall-hazard map (Knudsen and Lund, 2011, 2013) shows the house at 368 West Main Street destroyed by the December 12th rock fall was in a high rock-fall-hazard zone (figure 5), as are many other structures in Rockville at the base of the Rockville Bench. Based on similarities between the December 12th rock-fall site and other locations at the base of the Rockville Bench in western Rockville, in particular the lack of sufficient space to construct rock-fall-risk-reduction structures, rock-fall mitigation is likely neither practical nor cost effective in those areas as well. Therefore, residents within high rock-fall-hazard areas of western Rockville have two options: (1) accept the hazard and continue

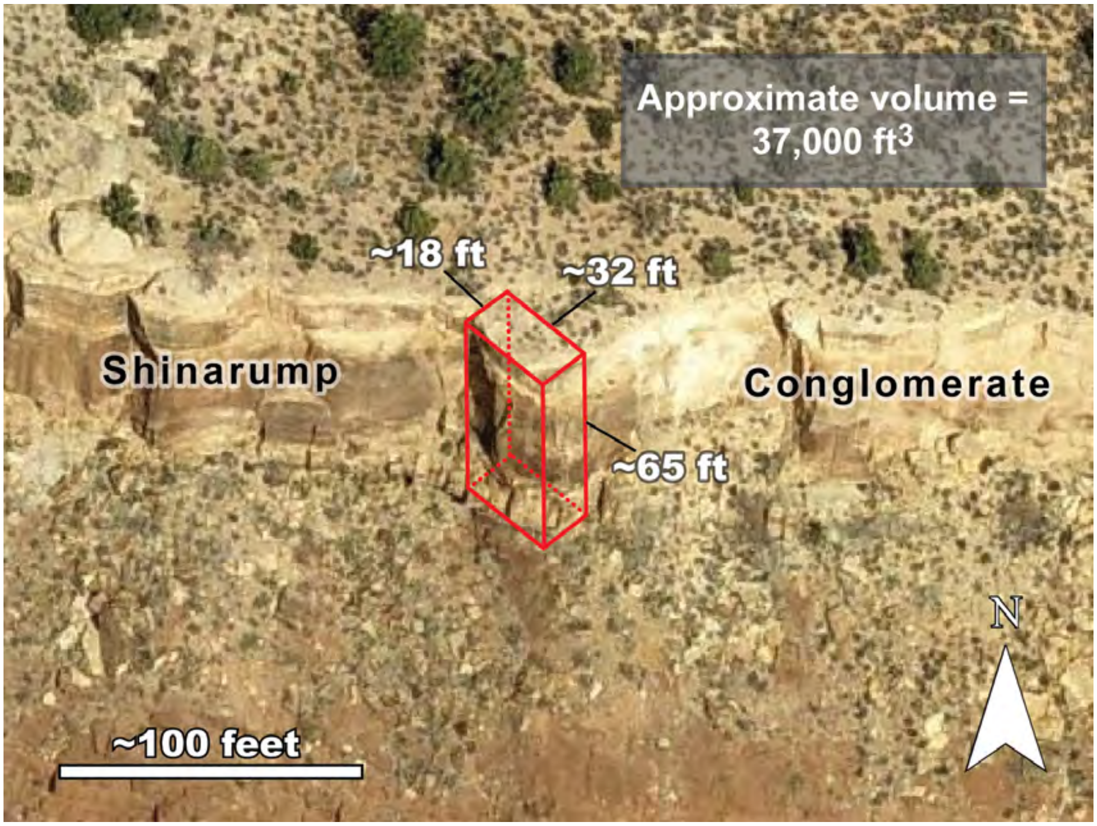

Figure 14. *Circa-2008 oblique aerial view of cliff face and source area showing estimated rock mass dimensions. Photo from Microsoft Bing Maps (http://www.bing.com/maps/).*

Figure 15. *The largest boulder to reach the December 12, 2013, rock-fall site. The boulder is situated within the debris of the destroyed house, and has an estimated volume of 270 yd^3 and mass of 520 tons; average boulder dimensions are 27 x 16 x 16.8 feet. Photograph taken December 17, 2013, view is to the north.*

Figure 16. *Second largest boulder to reach the December 12, 2013, rock-fall site. This boulder came to rest a few feet from the house on the property immediately east of the rock-fall site, and has an estimated volume of 250 yd³ and mass of 490 tons; average boulder dimensions are 38 x 13.75 x 13 feet. Photograph taken on December 17, 2013, view is to the southeast.*

Figure 17. *Boulder that destroyed the car during the December 12, 2013, rock fall; scale provided by a 1-meter stick marked in 10-centimeter increments. After striking the car, this boulder bounced across the remainder of the driveway (no gouge marks) before churning up and coming to rest on the lawn. The boulder has an estimated volume of 21 yd³ and mass of 41 tons; average boulder dimensions are 7.9 x 15.9 x 4.5 feet. Photograph taken on December 17, 2013, view is to the southwest.*

Figure 18. *Largest boulder to reach the property immediately west of the December 12, 2013, rock-fall site. The boulder has an estimated volume of 21 yd^3 and mass of 41 tons; average boulder dimensions are 7.5 x 11 x 7 feet. Photograph taken on December 17, 2013, view is to the southwest.*

to live in the high-hazard area knowing that the consequences of that decision could result in significant property damage and may prove fatal, or (2) relocate from high-hazard areas. Residents at the base of the Rockville Bench farther east in Rockville may, in some instances, have a third option where sufficient space is available to construct rock-fall-risk-reduction structures. Whether or not such measures are possible at a particular location would require detailed hazard and engineering investigations. Such investigations should include an evaluation of cliff-face stability above and adjacent (as rock fall may not follow a direct path downslope) to a site, including the potential size of future rock-fall boulders; the presence of gullies on the Moenkopi slope that may direct rock falls toward or away from a site; and the potential effectiveness of previously fallen boulders at the base of the bench to serve as rock-fall barriers. Note that if previously fallen boulders were to shatter upon impact with rock-fall debris, as happened in the December 12th event, rather than serving as rock-fall protection, they could increase the risk to structures and life at the site.

As the December 12, 2013, rock fall and Knudsen (2011) amply document, there is no question that future rock falls in Rockville will occur and have the potential to endanger the property and lives of residents who continue to reside in high rock-fall-hazard areas. It is the responsibility of the Town of Rockville to ensure that current and prospective future residents and land owners within high rock-fall-hazard areas are made fully aware of the hazard, so they can make an informed decision regarding their future course of action regarding rock-fall hazard.

It is unknown if funds are available from federal, state, or other sources to permit the Town of Rockville to either purchase and retire the properties of homeowners who wish to relocate from high rock-fall-hazard areas, or to move houses to safe locations outside of those areas. Similar kinds of actions have been taken by the City of North Salt Lake in response to damage from the Springhill landslide, and by Cedar City in response to damage from collapsible soils. We recommend that the Town of Rockville investigate the feasibility of taking such action. The Five County Association of Governments and/or the Utah Division of Emergency Management may be able to provide information on the feasibility of acquiring funding.

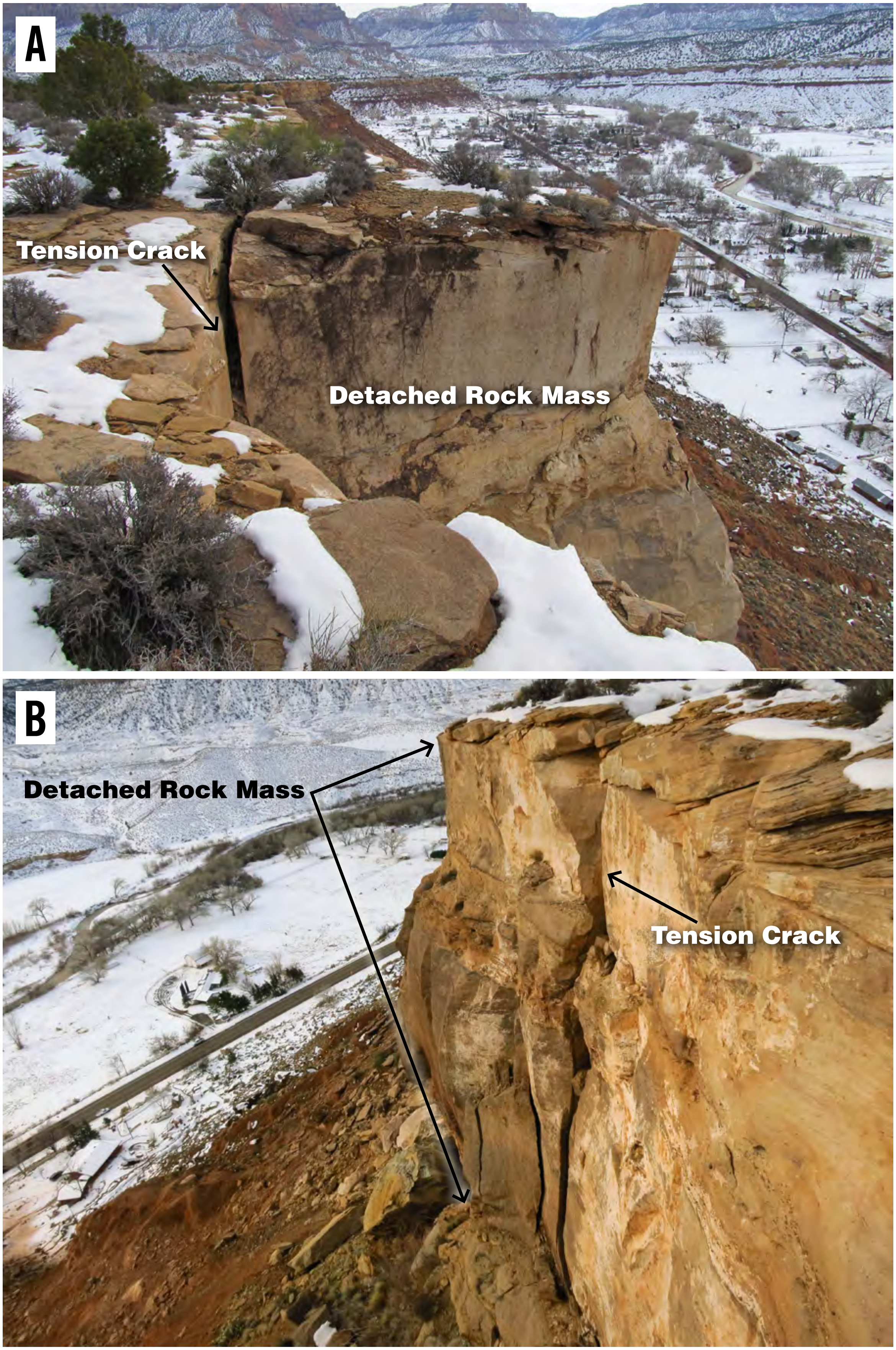

Figure 19. *Partially detached rock mass (A) view toward the east and (B) view toward the west still present at the face of the Shinarump cliff above the location of the December 12, 2013, rock fall at the time of this investigation. Photographs taken on December 13, 2013.*

Figure 20. *Two views showing structures endangered by rock falls along the base of the Rockville Bench in Rockville, Utah. (A) The white house in the foreground was struck by a rock fall in February 2010. (B) The house in the foreground is immediately east of the December 12th, 2013, rock-fall site and was struck by small rock-fall fragment; additionally, a very large boulder (figure 16) from that event came to rest only a few feet from this house. Boulders near homes in the middle and far distance are from previous rock falls of unknown timing.*

ACKNOWLEDGMENTS

Steve Gilbert (Gilbert Construction) made his helicopter available for the reconnaissance of the cliff above the rock-fall site. Kurt Wright (Springdale/Rockville Chief of Police/Incident Commander) provided every courtesy and access during our site visits, and accompanied us on the helicopter/foot reconnaissance of the cliff face above the site. Jack Seegmiller provided several photographs of the rock-fall event for our investigation. Technical review comments provided by Rich Giraud and Mike Hylland (UGS) and Keith Brown and Jon Bischoff (UDOT) substantially improved this report.

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APPENDIX

Utah Department of Transportation Letter

To

Town of Rockville Mayor Dan McGuire

State of Utah

GARY R. HERBERT
Governor

SPENCER J. COX
Lieutenant Governor

DEPARTMENT OF TRANSPORTATION

CARLOS M. BRACERAS, P.E.
Executive Director

SHANE M. MARSHALL, P.E.
Deputy Director

December 23, 2013

Mayor Dan McGuire
Town of Rockville
43 East Main
Rockville, UT 84763

Dear Mayor McGuire,

At the request of UDOT Executive Director Carlos Braceras, Keith Brown and Jon Bischoff of the UDOT Geotechnical Division visited the location of the December 12th, 2013 rockfall event that occurred in Rockville, Utah. This is a summary of that site visit.

On December 17th, 2013 we met with Utah Geological Survey (UGS) geologists Bill Lund, Tyler Knudsen, and Steve Bowman. They briefed us on the rockfall incident investigation they are conducting regarding the December 12th rockfall event. We were also provided a copy of a published rockfall hazards map produced by UGS and a 2010 report discussing rockfall hazards in this area. The map classifies this site and the surrounding areas as having a high rockfall hazard. UGS confirmed that rockfall within the defined high hazard zones can occur frequently and without warning. We are in agreement with the UGS assessment of the high rockfall hazard at this location.

On December 18th, 2013 we visited the subject site and observed the size and quantity of the recent rock fall. The large amount of existing rock on the slope and the many very large boulders near the affected properties is evidence of the countless rockfall events at this location over the ages. While on site we met Rockville Mayor Dan McGuire and Town Councilman Jeff Ballard. We were specifically asked if there were measures that could be taken to prevent rockfall at this location or to mitigate the rockfall hazard at this location. We explained that rockfall mitigation technologies such as rockfall fences or catchment ditches would be ineffective due to the large size and high energy of the typical boulders involved. The cost of prevention strategies such as rock bolting the cliff areas would greatly exceed the value of the endangered properties and the effectiveness would be questionable. Efforts to continuously monitor the cliffs utilizing existing technologies would also become excessively expensive over time.

In summary, this is an area of high rockfall hazard. We do not know of any mitigation or prevention strategies that could effectively protect the properties in these high hazard areas in a cost effective manner.

If you have any questions, please feel free to contact me at (801) 633-6238 or Jon Bischoff at (801) 633-0094.

Sincerely,

Keith Brown, P.E.
UDOT Chief Geotechnical Engineer
kebrown@utah.gov

cc:
Jeff Ballard, Rockville Town Councilman
Carlos Braceras, UDOT Executive Director
Shane Marshall, UDOT Deputy Director
Randy Park, UDOT Director of Project Development
Carmen Swanwick, UDOT Chief Structural Engineer
Bill Lund, UGS Senior Scientist