REPORT ON RECONNAISSANCE OF A PORTION OF HIGHLAND ESTATES SUBDIVISION (FIRST FILING) GILLETTE, WYOMING

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INTRODUCTION

The Environmental Section of the Geological Survey of Wyoming was asked by the Wyoming Department of Environmental Quality to determine if recent earthquakes in Wyoming were responsible for damage to homes in the Highland Estates subdivision in Gillette. It was determined that only a field examination could determine that possibility, although it was felt that the earthquakes did not have a noticeable effect. This paper is a report of a quick reconnaissance of the area. It is not intended to be an in-depth analysis. The area that was observed in the field is shown on the enclosed map. It was determined that the damage was not earthquake related. Instead, it appeared to relate to compaction and slope stability.

BACKGROUND

The first step in a study of this type is to determine what has taken place in the past that could be affecting the present.

In order to partially reconstruct the cutting and filling history of the subdivision, the following information was utilized:

1968 aerial photography - Intrasearch color photography

1971 topographic map - U.S. Geological Survey

1975 topographic map superimposed on an aerial photograph of the subdivision

1978 aerial photography - Bureau of Land Management, Color I.R.

Recent large scale aerial photograph

It appears that before 1976, much of the subdivision area was cut, levelled, and filled. In fact, based upon a comparison of the 1971 and 1975 topographic maps, it appears that the crest of the highest knob near the eastern edge of the subdivision may have been lowered up to 24'.

There appear to be two areas that were extensively filled before 1976. A southwest to northeast trending area that underlies the northwestern half of Lafayette Drive appears to be composed of multiple layers of fill. The edge of it extends beyond the subdivision into private land. Another area of early fill is north of the eastern third of Crestline Drive. The upper portions of a series of erosional cuts and gullies were covered by that fill. All areas of suspected older fill are shown on the enclosed map.

Since early 1976, there has been additional cutting and filling in the subdivision. Most lots that bordered on a steep slope were apparently partially filled and leveled. Most of the homes exhibiting damage were located in those areas.

OBSERVATIONS

There is one area of the subdivision along portions of Foothills Boulevard and Lafayette Drive that is experiencing severe damage to houses, garages, foundations, and fences. That area is north of a line extending from the eastern edge of the subdivision along Foothills Boulevard up to Lafayette Drive and then down the complete length of Lafayette Drive. That was the only part of the subdivision examined by the Geological Survey of Wyoming.

Only two houses were examined closely, the Slater house at 804 Lafayette Drive and the Brinkman house at 2900 Foothills Boulevard. Most estimates of the

causes of existing or potential damage to other houses in the study area can be derived from observations on Slaters' and Brinkmans'. Both of those residences have been evacuated due to severe damage.

Fill

As mentioned earlier, many of the damaged homes appear to be located on filled areas. There have been at least two episodes of filling in the study area. An older fill is found below the northwestern half of Lafayette Drive and is composed of layers of broken bedrock (shale, coal, siltstone) and weathered bedrock (sandy, clay, silty clay). Newer fill was put over both the older fill and the previously unfilled area to the southeast. The new fill was put in so as to provide a level surface on which to construct Lafayette Drive and the houses northeast of it.

It is not known how much fill was placed southwest of Lafayette Drive. It is estimated that up to 10 feet of the newer fill could have been placed under portions of Lafayette Drive and the front yards of the houses to the north and east of it. The new fill tapers down in the backyards of most of the houses observed, and generally, does not appear to reach the rear property lines. As most of the houses have walk-out lower levels, the bulk of the fill is on their sides and fronts (street-facing side and/or uphill side). It is assumed that the footings for the foundations are placed in new fill, although that may not be the case for the homes located over the old fill. Construction records and boreholes will show what thickness and age of fill underlies the houses. An observation that merits further study is that it appears that the houses that have been placed over the older fill are more stable, even if new fill covers the old. A probable cause is that the slope of the top of the old fill is not nearly as great as the slope of the surface covered by new fill only.

Damage Factors

There are three possible factors causing damage in the area. They are fill compaction (uniform and differential), creep (very slow flowage of materials), and shrinking-swelling clays. All of these processes may be taking place in the fills and weathered bedrock.

Creep

Creep is very evident in the study area. It appears to be active in both the new fill and the underlying weathered bedrock. The effects of creep are most obvious along the fences in the backyards of the houses of interest. In many cases, the fences on the sides of the yards have posts tilted in an uphill direction, indicating downhill movement of the material in which they are anchored. In other cases, the fence lines on the sides of the yards are deformed into an "S" shape. This indicates that lateral movement has taken place.

Many of the fences bordering the rear of the lots are bulged outwards in a downhill direction. Those fences should be anchored in weathered bedrock, and not fill as with those on the sides of the lots. The fact that they are bulging indicates that either the weathered bedrock is creeping or the effect of the creeping mass of fill has reached the rear lot line.

If the creep is present in the backyards, it is possible that it is also taking place above, under, and on the sides of the houses. One way to accurately document the presence of creep is to drill a series of bore-holes and monitor the deformation in the holes over a period of time. A series of stakes lined up in a grid pattern will also show evidence of movement if creep is present.

Shrinking-swelling clays

There is a possibility that shrinking-swelling clays can be causing some of the damage. The clays can damage houses in a manner similar to what has occurred (buckled floors, cracked walls, tilted slabs). The composition of the fill and the underlying weathered bedrock needs to be determined in order to estimate the role that shrinking-swelling clays play in the destruction. Detailed samples of the fill and underlying bedrock need to be taken at various depth levels at a number of locations. Each sample should then be analyzed for shrink-swell capacity.

Compaction

There are signs of compaction in the study area. Some of the houses, patios, and garages appear to have settled. We were informed by Mr. Rick Slater that the first apparent damage at his house occurred on a front patio slab (approximately 16' X 4' X 1' of concrete). The street side of the slab subsided, resulting in extensive cracking. The slab apparently was replaced, but the front side subsidence occurred again. At the time of the slab subsidence, there was only minimal damage to the rest of the house.

The front (street side) of the Slater house has now exhibited signs of apparent subsidence. It is approximately 6" lower than the rear of the house according to Mr. Slater. The street side of all the floors (basement and upper level) are lowered by that approximate amount. In addition to the forward tilt, both sides of the house are apparently subsiding at a greater rate than the center. Adding more confusion to the picture is the apparent partial collapse of the garage. It is tilting forward at a greater angle than the rest of the house. Possibly, the tilt given to the rest of the house was sufficient to cause the garage to slowly destabilize. Another

factor that could have affected the garage and the foundation under it is the loading and unloading effect of driving a car in and out.

At first glance, it appeared that the Slater house was located on the upper bench of a small rotational slump block. Some of the indications of slump are uphill rotation and numerous cracks in the basement. However, there are no observable head or lateral scarps (zones of rupture) in any portion of the yard, and no observed evidence of a distinctive flow lobe (foot and toe of a complex slump) overriding any portion of the yard. A sketch is provided to illustrate the types of features that are commonly observed with slumps. If a typical slump had occurred, some of the illustrated features should have been observed.

There may be evidence for small scale slumping in Slater's backyard. He mentioned that from time-to-time, cracks have been noticed in one of the flat terraced areas. The cracks could be those that commonly form in the upper parts of slumps. Unfortunately, we did not observe the cracks as snow covered the yard.

As mentioned earlier, Slater had problems with a tilting patio. If the patio was on a slump block, the house would have to be on the same block. Therefore, if the patio tilted in response to movement of the block, the house would have tilted an equal amount. However, the patio and house apparently tilted at different times and different rates. That, in addition to the previously mentioned lack of slump features other than tilt, raised doubts about the slumping theory.

A possible explanation for the tilting of the patio slab is differential compaction. It is assumed, although not proven, that the fill under the slab was more compactable and/or deformable when moist than when dry. If that is the case, a combination of front yard watering, rain, and snow-

melt may have wetted the fill under the front portion of the slab to a greater degree than under the rear portion which was partly protected by a roof. It is assumed that the fill gradually decreased in water content from front to rear. This could lead to the patio compacting the fill in a non-uniform manner, resulting in a tilted slab.

The same problem could have occurred with the house, only it would have taken longer to moisten the fill around and under it. The layout of the flat and sloped filled areas would exert some control on the distribution of water. Water would have a tendency to percolate downwards in the flat front yards and flow over the surface of the fill in the sloped backyard. This would result in fill that is more moist in the front yard and under the front portions of the house.

As the foundation walls on the sides of the Slater house are not covered with fill, any water that falls there would more directly seep into the fill below the sides of the house. However, as the steep slopes on the sides of the house dip towards the back of the yard, some water would also run off. For that reason, it is assumed that not as much water would be present in the fill underlying the sides of the house as under the front.

The result of the scenario for Slater's home is that the house would not only tilt forward, but also sag at it's sides. This could be due to minor moisture differences in the fill, with the more moist fill under the front and sides of the house compacting to a greater degree than the fill under the rear.

Without hard evidence, the above statement is conjecture. It is necessary to determine what type and amount of compaction has actually occurred. It should be possible to compare the degree of compaction of the fill in its present state to its pre-construction state, if tests were done before construction. If those tests were not done, it might be possible to compare the degree of compaction of the fill in the open yards to the fill under the garages and houses. In this manner, it might be possible to determine how much the fill has compacted at various locations. It might also be possible to compare the degree of compaction with moisture content under ideal conditions. Hopefully, there are standard engineering testing procedures that can apply.

CONCLUSIONS

Although reference was made to only a few houses in the report, the processes that have taken place around them either are occurring or could occur in other selected homes in the study area. Without the information on the shrink-swell capacities, degree of and susceptibility to compaction, and the rate, depth, and extent of creep in the fill and underlying weathered bedrock, it is almost impossible to determine which of the factors is dominant. For the time being, unless proven otherwise, it is assumed that all are active. Although the Slater home was used in the compaction scenario, it is highly probable the other two factors are also exerting their influence on that house.

For example, it appears that the front foundation wall of the Slater house is buckling to a degree. While the buckling may be caused by the downward movement of that portion of the house, it could also be from forces exerted by shrinking-

swelling clays. The presence of those clays doesn't preclude compaction. In fact, if the load is sufficient, expansive clays may compact more than certain non-expansive clays. It is possible to have a house located on shrinking-swelling clays and have the concentrated downward force on the foundation walls great enough to either prevent upward movement or to cause a degree of compaction. However, the basement floor slab may buckle as its downward force is spread over a large area, and at any point the upward force exerted by the expanding clay may be greater than the downward force.

If materials are prone to creep, then loading or moistening them usually accelerates the process. Oftentimes, materials that creep are also prone to compaction and shrinking-swelling. It is possible that compaction of the fill at the fronts of the houses can be promoting creep below and behind them.

RECOMMENDATIONS

Only with more extensive tests to determine the properties of the fill and weathered bedrock can an accurate determination of the causes of the destruction be made. A few basic tests have been suggested in this report. A qualified engineer may be able to develop many more.

The tests or further studies that have been suggested in this report are as follows:

1) Determine the degree of damage to the houses located over the older fill under the northwestern half of Lafayette Drive. It is possible that old fill is slowing the destruction process, although not completely stopping it.
2) Devise a system for monitoring creep. A possible method is to drill a series of holes and monitor them for movement. Another possibility is to design a grid system for stakes that will readily show any signs of movement.

3) Take numerous core samples of the fill and underlying bedrock throughout the disturbed areas, and test various levels of cores for shrink-swelling capacity.

4) Devise a system for measuring degree of compaction and try to relate it to moisture content, shrink-swell capacity, or other factors that may be present in the fill or weathered bedrock.

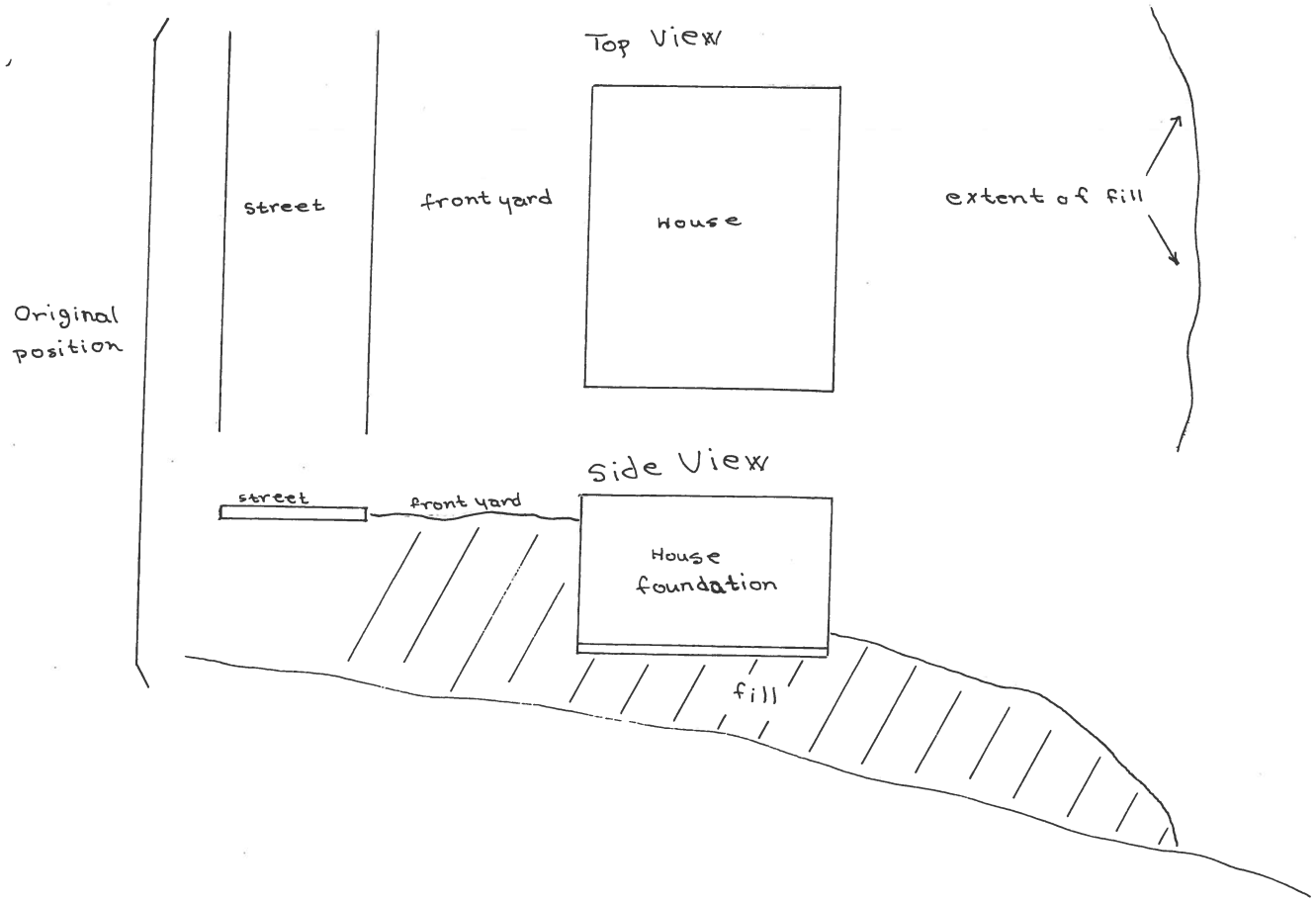
5) Although this was not suggested earlier, it may be of use. If accurate measurements of the amount of tilt of various features were taken, it could help to determine what factors are dominant.

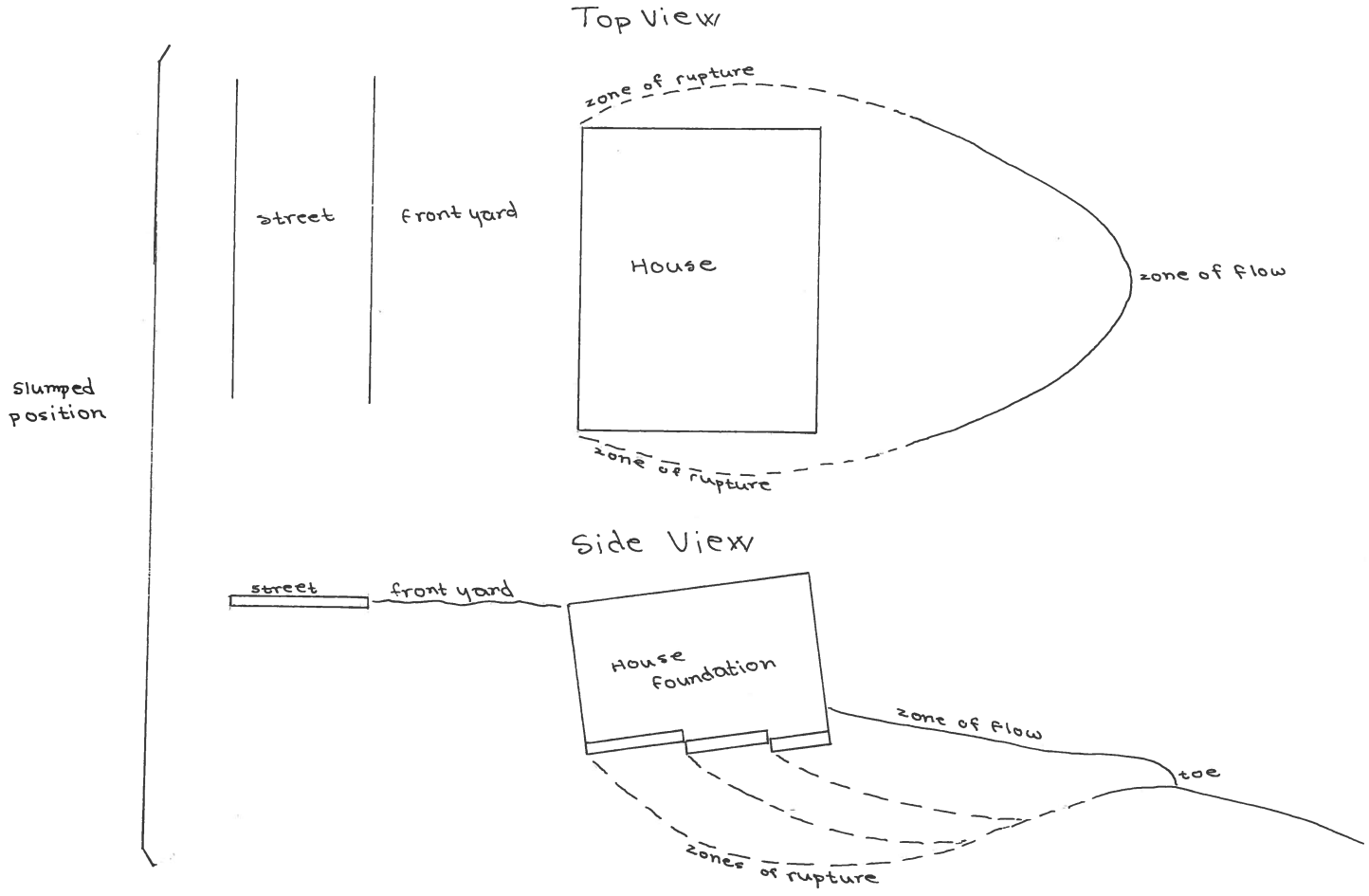
   For example, if all the floors of the disturbed houses are tilting in the same direction, it may indicate that similar processes are taking place. If the floors are tilting in different directions, a unique combination of factors could be occurring at each house. The same may hold true for major cracks and offsets. Through this process, it may be possible to determine if the foundation walls and floor slabs are deforming in the same manner. It is possible that some foundation walls are on material that is compacting due to the weight. The floor slabs may be more subject to shrinking-swelling clays than compaction as the weight of the slab is spread out over a large area.

6) Survey the homes north of Crestline Drive to determine if any damage is occurring. Some of them are located over older fill.

Although the above analysis is general and based upon a short reconnaissance, it is hoped that some of the discussions will be useful in future studies. The

most important single point that can be made is that it appears that compaction, creep, and shrinking-swelling clays may all be occurring in the area. Only through methodical and extensive testing can the exact destructive factor or combination of factors be determined.


Top View
street
front yard
House
extent of fill
Original position
Side View
street
front yard
House foundation
fill


Top View
zone of rupture
street
front yard
House
zone of flow
slumped position
zone of rupture
Side View
street
front yard
House foundation
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