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A Study of Sensitive Lands in Provo

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A STUDY OF
SENSITIVE LANDS
IN PROVO

A Thesis
Presented to the
Department of Geography
Brigham Young University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
Doris R. Monson
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This Thesis, by Doris R Monson, is accepted in its present form by the Department of Geography of Brigham Young University as satisfying the thesis requirement for the degree of Master of Science.

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CHAPTER I

Introduction

Purpose

Land is a resource. It is a natural element of which there is only a limited amount. If it is abused then future generations will suffer because of the abuse. Therefore some kind of regulation should be placed on the use of land to insure that it is not recklessly destroyed.

However, not all land is equally damaged by the same type of use. Some areas are much harder than others and do not need to be closely regulated in order to survive man's land developments. Nevertheless, some lands are easily damaged and poor developments can irrepairably harm them. These lands, the "sensitive or critical land" areas, need more protection than do other areas from the thoughtless actions of man. It is because of the need to protect these critical lands that this thesis has been written.
Justification

The following maps illustrate the sensitive land areas in Provo, Utah. Because much of Provo is found within the critical lands areas there is a need to study these lands.
HILLSIDE GEOLOGICAL STRUCTURES
SOIL CONSTRUCTION SUITABILITY

- Hazardous
- Marginal
- Standard

GEOLOGIC HAZARDS
- Fault Trace Well Exposed
- Fault Inferred
- Landslide Areas

Map 2
Sensitive Lands Practices of Other States

Provo is not the only area with sensitive lands problems and regulations. Other states face the same types of problems. At least nineteen states have sensitive lands regulations in some form or another. Some of these regulations are enacted at the state level and some at the local government levels. A brief look will be taken of the following states: California, Florida, Hawaii, Maine and Washington.

California has a combined state/local sensitive lands use regulation. They have designated thirteen classes of "Statewide Critical Concern" areas (Summary Report, California Office of Planning and Research, 1973).

1) Park, reserve and wilderness areas
2) Recreation, access and connecting links
3) Historic, archeological and cultural resources
4) Wildlife habitats
5) Forest lands
6) Agricultural lands
7) Mineral areas
8) Water sources
9) Energy sources
10) Geological hazard areas:
   a. Earthquake shaking
   b. Volcanic eruptions
   c. Tsunami
   d. Fault displacement
   e. Landslides
   f. Subsidence
   g. Erosion activity
   h. Expansive soil
11) Fire hazard areas
12) Flood-prone areas
13) Critical air areas
All sensitive lands regulations deal with one or more of the classes of areas mentioned above.

There are five specific sensitive land areas that are governed at a level greater than the local level. They are:

A. The coastal area. In order to build along the coastal zone, a permit is required from regional coastal zone district commissions for development up to 100 yards landward from mean high tide. This law protects coastal wetlands (Linowes, p.105).

B. The second zone deals with the San Francisco Bay. A permit is required for any filling of the Bay or land within 100 feet of the Bay. The permit must be obtained from the San Francisco Bay Conservation and Development Commission.

C. The third category is Lakeshore areas, particularly Lake Tahoe. The counties of Placer and El Dorado may have their local controls superseded by the Tahoe Regional Agency, if the Agency feel local controls are not stringent enough to protect the land surrounding Lake Tahoe.

D. Scenic rivers is the fourth critical land area. This category is under state regulation. The state designated wild, scenic and recreation rivers and
prepares a management program for them. The state also regulates dams reservoirs and impoundments.

E. The last category is the floodway areas. Here the state establishes minimum standards for local flood plain regulation. If the local governments fail to adopt flood plain standards then they lose state funding for cost sharing in flood control projects.

These are the five basic categories in which the regulations are set by authorities above the local level. The rest of the regulations, such a development in seismic areas, rests with the local governments (Kusler, pp. 178,192).

Florida designated four classes of land as "Areas Critical State Concern."

1) Area containing or having a significant impact upon environmental, historical, natural, or archeological resources of regional or state wide importance.
2) Area significantly affected by or having a significant effect upon an existing or proposed major public facility or other area of major public investment.
3) Proposed areas of major development potential which may include a proposed site of a new community designated in a state land development plan.
4) An area subject to periodic flooding (Florida Environmental Land & Water Management Act of 1972, Section 380.05).

Because of the intensive development within these classes of land the state of Florida developed a
Comprehensive Critical Areas Act. Under this act the state designated areas of critical state concern and formulated minimum development standards. They then required local governmental units to adopt regulations consistent with the state standards. If the local units chose not to do so the state has the power to directly regulate the land use of the sensitive areas within the local municipality's jurisdiction.

The state government has also set a 50-foot setback from mean high water for any type of construction or excavation. This helps prevent coastal erosion (Kusler, pp.177,199).

Hawaii is another state concerned with coastal erosion. Like Florida, they have established a 50-foot setback along the beach front to minimize erosion problems. This state also has done something no other state has done, i.e., establish state zones for all islands. All land is found in one of four zones: urban, rural, conservation and agriculture. The state has exclusive power over conservation zones, but allows local regulations to apply to other areas (Kusler, p.178).

The state of Maine defines critical areas as "areas containing or potentially containing plant and
animal life or geological features worthy of preservation in their natural condition, or other natural features of significant scenic, scientific, or historical value" (Maine State Register of Critical Areas Act of 1974, Section 3312).

Much of the sensitive or critical land regulations in Maine are controlled at the state level. Four of the six land use categories come directly under state government regulation. The other two are regulated to the local governments, with standards set by the state government.

The first class of state regulation deals with unorganized and disorganized areas. The Maine Land Use Commission regulates land in unorganized territory, plantations and towns.

The second is site review of large scale development, where the Maine Board of Environmental Protection regulates development which "may substantially affect the environment" including subdivisions and most developments that are over 20 acres or with structures which occupy more than 60,000 square feet (Kusler, p.178).

The third class deals with coastal areas. The state of Maine prohibits any discharge of oil,
petroleum products, or their by-products into or upon any coastal waters, estuaries, tidal flats, beaches, adjoining lands or waters which drain to the coast. Also, any oil terminal facilities must have state approval before construction (Linowes, p.97).

Along with state regulation, local governments give local permits required for filling, dumping, dredging or sewage discharge into coastal wetlands. However, the state holds the privilege of disapproving a permit.

Maine also inventories and creates a register of "Critical areas" of significant natural, scenic, scientific or historic value. The state is also to receive notice of any proposed developments that occur within such spots. No development is to take place within the area for sixty days after notification without the approval of the state. Therefore, the State has direct control over what types of development go into their critical areas.

The category of shorelands, which includes lakes, streams and coastal areas have standards set by the state government for local regulation. Along with their standards is a mandatory local shoreland zoning within 250 feet of the high water mark of water
bodies. If a local government does not enforce this zone, then the state will (Kusler, p.178).

The state of Washington has turned all regulations over to the local governments. The only thing the state has done is adopt standards outlining the direction for the local units.

For the flood plain the state regulated flood plain areas by designating flood control zones and issuing the permits for development therein. However, the state will not preempt local programs, and the state may delegate its powers to local units (Kusler, p.184).

An interesting case with the power of local units is found in King County, Washington. This county has mapped all of their sensitive lands. Their definition of sensitive lands is lands subject to destructive natural hazards or which support in the natural or existing state certain unique, fragile or valuable environmental and ecological features. These lands include lands subject to high erosion potential, sliding or slippage, high earthquake sensitivity, or which are underlain by coal mines, natural wetlands or streams, rivers, and other water bodies which support anadromous fish life (King County Development Assistance Bulletin, p.1).
Any land that is designated as sensitive lands upon the map must be reviewed to determine if the proposed development on it will have significant impact to the sensitive area. If an impact will occur then a special study of such impacts and any potential problems must be made by the developer. The study is then evaluated and a decision is made whether to approve the project, given a conditional approval, or deny the permit. Just because the study is performed, it is not guaranteed that the developer will be allowed to develop his property (King County Development Assistance Bulletin, pp.1-4).

Each of these states has had to deal with their sensitive lands differently. This is because the land varies from place to place. Therefore, in order to cope with the problems different regulations have to be enacted by the state and local governments. However, all five of these states have one thing in common. They all have some type of state control over their sensitive lands.

In some states like Hawaii, the state directly controls what the land can be used for. In others like Washington, the state level of government sets the standards and lets the local governments make their own
laws to enforce the standards. Either way the state can pressure a municipality to enforce the state standards or else have their lands directly controlled by the state.

These standards can be an effective back-up support system for a municipality. It can help a regulation be enacted despite the negative response of the developer. For if the local government does not enforce the state standards, the state will step in and do so.

One of the problems that Provo faces with its sensitive lands regulations is that Utah does not have any state critical lands standards. Therefore it is up to the individual cities like Provo to try to protect their land from misuse and/or harm. They are not obligated to uphold a certain development standard for the sensitive lands within their jurisdiction, so if the development pressures become too great for a city, the city can just change or ignore the breaking of its land use regulations.

Due to the lack of state standards Provo has lagged behind other areas like King County. It did not finish adopting its Sensitive Lands Ordinance until 1981. By that time much of the problem areas had
developed without many guidelines. The citizens have also resisted the efforts to regulate the sensitive lands. Because of this resistance, Provo has had difficulty in enforcing the standards they have set. Often compromises have to be enacted because political pressures can be placed upon the subdivision and zoning departments by the developers, and without authority from the higher levels of government there is not enough support to override the pressure.
CHAPTER II

Sensitive Lands

Some lands need to be more closely regulated than others. These lands are called "sensitive land areas" or "critical areas." There are two major sensitive land categories: land that is potentially hazardous to man, and lands easily damaged by man's activities.

Geological Hazards

One area hazardous for land development is where the geologic structure is unsound. These areas contain unstable soils and rock structures.

Soils comprised of "fine mineral particles intermediate in size between sand and clay" or silt, tend to be unstable (The American Heritage Dictionary, p.1206). As long as the moisture content is low then silt soils can support whatever is on the surface. However, once the moisture increases the bond between silt particles is weakened, so they readjust their bond surfaces. Normally there is a large volume of open space between the silt particles. With readjustment the space diminishes, with each silt particle moving
closer together. The same amount of silt takes up less space and becomes more dense or compacted. In the process the silt is said to collapse or settle (Hillside Study, p.7).

If there are structures on top of this type of soil they will shift and undergo a settling process as the soil becomes saturated, densifies and then collapses.

Another unstable soil is clay. It has very small pores and fine particles. Therefore, it is impermeable to water. If there is too much water in the clay it becomes sticky and will easily slide (Hidore, p.139).

If too much water collects on top of clay, pressure begins to build. Once the pressure is greater than the force of gravity holding the soil in place, the clay slides down its slope until the two opposing forces are at equilibrium again.

If the geological structure of an area is fractured, that fracture is called "a fault line." Rocks along this fault are subject to vertical and/or horizontal displacement caused by any seismic activity.

Often faults lie underneath the surface and are difficult to map, making it easy for the unknowing individual to build over them. However, when an
earthquake occurs, the shock tremors and the displacement of the underlying rocks can cause severe damage to any structures above.

**Damageable Lands**

One of the amenities of a home is in the scenic view it provides. The better the view is, the more desirable the home becomes. Often mountains provide beautiful views, thus stimulating the development of homes up the side of the mountain. Unfortunately mountains are one type of land that is easily damaged. As homes are developed there, millions of cubic yards of earth are moved, often with little attention given to the underlying geologic, soil or drainage conditions.

One of the first things hillside development does is remove vegetation. And once it is removed, the slopes are exposed to the eroding power of the wind and rain.

This happened in the Los Angeles area in the 1950's. The flatlands adjacent to the metropolitan areas began to fill with people. This created pressure for hillside developments surrounding Los Angeles.
With the coming of each rainy season, it became apparent something was wrong because these areas had severe problems with erosion, land and mudslides (Hillside Study, p.1). These resulted from the destruction of mountain vegetation. In a dry area such as Southern California, the vegetation destroyed by development was unable to rejuvenate itself before the heavy winter rains came. There was nothing to catch and hold the water so it was free to rush down the mountains unhindered, bringing with it loose soil. This erosion can have serious consequences. It leads to slope instability, which in turn, leads to earth movements, such as land and mudslides, and slumps (Hillside Study, p.3).

The removal of vegetation helps create slope instability because it removes the root system. Roots intertwine within the soil, acting as a net to hold it in place. Without this support slopes give way and slide much more readily than they do with the root system.

In addition to the above, man undermines the mountain by cutting away the sides. When a portion of the mountain face is cut and leveled for a road or building foundation, there is less support for the
hilside above that cut. If the pressures pushing against the mountains are greater than the support of the underlying rock, the earth above the cut gives way and moves down the hillside in a rockslide, slump, mudslide, soilcreep, etc.

If the underlying structure of a hillside is composed of an unstable soil or rock then the danger for earth movements is even greater when man changes the face of the hill. Examples of unstable elements are clay and shale. Clay is a problem because it will slide easily and if its support is gone there is nothing to hold it in place; thus, it will slide down the slope in the form of a land or mudslide. Shale, on the other hand, is not bound together like clay. Instead, it is in layers separate from each other in a delicate balance. If something disturbs that balance rocks roll down as a rockslide until something stops them.

The problem with disturbing mountainous areas is that changes to their form tend to be permanent. Sloped areas cannot be rebuilt the way level farmland can. If a farmer needs to replenish the soil he can fertilize and grow certain crops that will help return the soil to its original form. However, once a mountain
has its face worn away to bare rock it takes thousands of years for the weathering process to create enough soil to cover the face again so that life can be maintained.

**The Flood Plain**

Another place that can be considered a sensitive land area is the flood plain. Flood plains are where a river or lake spreads out during a spring runoff or heavy rainstorm. These plains form over the years as rivers loop back and forth between their confining banks. The valley gets lowered as the riverbanks are gnawed away. This creates a flatbottom stream with low banks that may easily be topped as the river or stream rises (Brainard, p.212).

A flood plain may not be as easily disturbed as a hillside, but it is still possible to affect it. Flooding can be increased by the removal of vegetation from the mountains, causing an increased rate of runoff. Leaves and branches slow the rate that water hits the ground so it percolates rather than rushes through the soil. If this protective covering is removed precipitation is not slowed down. The increased runoff rate pours more water into the streams
and rivers than normal. At the same time water flow over bare earth erodes away the soil. This eroded soil increases the volume of water in the streams and rivers, thereby increasing the chance of flooding (Ayers, p.13).

Man-made developments also increase the risk of flooding. With impermeable surfaces like asphalt roads and parking lots, water is unable to sink into the soil. It runs down the hard surface to a storm gutter, eventually emptying into a stream and increasing the amount of water the stream is carrying. This has the same effect as increasing the runoff through mountain vegetation removal. When runoff substantially increases, then flooding occurs. The problem is compounded when man builds on the flood plain. Property and life can be threatened. A prime example is when people build in washes and gullies. During a heavy rain these washes and gullies can fill with more than twenty feet of water. One man who lived on the edge of a wash in Los Angeles explained what happened in his neighborhood during some heavy winter storms. "The water lapped at the side of my house...Yesterday when the river rose I saw three houses on the side of the stream collapse and tumble into the flood," (Ayers, p.112).
High Water Table

A high water table is included in the sensitive lands definitions because it is easy to affect through man-made developments and can have the same effects as flooding. A water table is the highest level of ground water. If this ground water is high enough it seeps up through the ground to pond on the land surface. A marsh is then formed. Often the groundwater may be just under the surface and a wet winter causes the water table to rise and flood the bottom level of any buildings within the high water table area.

Man can develop hazardous situations with ground water by pumping it. When the water is removed, the pressure supporting the earth above it is gone. The earth then collapses down into the space once occupied by the ground water, creating holes (Goudie, pp.201-202).

When the ground collapses, it takes with it anything that happens to be on the surface. People and property can be swallowed up.

All of these elements make up what is called "sensitive lands." They are lands whose balance can be easily disturbed by man or upset by nature. Both disturbances may have disastrous results.
CHAPTER III

Sensitive Lands in Provo

With the growing awareness of the problems of sensitive lands, many cities and counties are considering regulations to protect these areas from misuse and their citizens from possible danger. Provo is one city where misuse of sensitive lands had been increasing. Wetlands were being filled, changing the filtering process in these areas. Hillsides were being developed and causing problems with land movements, erosion and storm drainage (Hillside Study, p.1).

Hillside Study

In 1977 the Department of Community Development conducted a hillside study to find solutions to problems that resulted from poorly designed building developments along the Wasatch mountains in Provo.

The study concluded that most of the hillside area in Provo is not suitable for buildings ("hillsides" are considered any area with a slope over 10%).
Map 1 shows the mountain slope. The majority of the hillsides are over 30% grade, above the 25% limit set by the city.*

Map 2 shows the geological structure of the Wasatch mountains. They are comprised of three basic time periods: Precambrian, Paleozoic and Cenozoic. The geological formations from the Precambrian era tend to be the most stable. They are the hardest and have the least fractures. Areas formed of this rock are the safest on which to build. However, this rock is usually found where the mountain slope is 30% or greater.

Younger formations tend to be softer with more fractures, creating potential problems for buildings constructed on these types of rocks. Unfortunately, these formations are generally found on gentler slopes where most construction takes place.

One reason these rocks can be so dangerous is due to the active fault lines running through the Wasatch mountains. Any seismic activity causes the rock to move along its fracture lines. If there are any

*25% is considered the maximum buildable slope. Anything built above that limit may cause severe erosion, drainage problems and earth movements.
man-made structures on top of these faultlines, they can be destroyed when the ground underneath shifts and/or gives way.

The study also analyzed soils in this area. It was found that the majority was a combination of silt and sand (Hillside Study, p.8). In many areas the sand is collapsible, i.e., whenever the silt becomes saturated with water the silt particles "collapse" or come closer together and the ground settles, or drops.

The other type of soil found in great quantity is a combination of clay and silt (Hillside Study, pp.34-36.). This, too, presents a danger for development. If the clay becomes saturated with moisture it slides easily.

The conclusions of the engineering company, Rollins, Brown and Gunnell, Inc., that conducted this study were:

1) A majority of the silts in the study area have a collapsible soil structure and are then susceptible to excessive settlement if saturated.
2) Silt slopes in northeast Provo are easily eroded and should be protected in critical structural areas. In order to maintain an adequate safety factor when the slopes are saturated, the slope should be no steeper than a ratio of 2.5 to 1.
3) Clays weathered from the Manning Canyon Shale in north Provo tend to be slightly expansive. Clays in the central and south portion of the study area are generally over consolidated; therefore, they should be able to carry normal residential loads without severe problems.
4) Soil cover on the steep mountain slopes along the east edge of the study area could slide downhill if this soil cover is ever saturated and is stressed greater than its natural shear strength (Hillside Study, pp.32-33).

The engineering group then suggested that:

1) All builders or homeowners should be advised of the settlement problems when their structures are being built on the collapsible silts and fine silty sands. The structure should be designed to prevent the soil from becoming saturated.

2) Construction should not be allowed on the slopes consisting of collapsible silts in the north Provo area unless a slope stability analysis is performed to determine the allowable loads and slope cuts.

3) A coordinated erosion control and drainage plan be developed to prevent excess erosion and flooding in the silts and fine silty sands.

4) As extensive subsurface investigation, foundation design study and earthquake analysis be required for any structure built on the steep slopes in the east part of areas P-13 to P-15 and P-20 to P-22.

5) A subsurface soils investigation be required for all non-single family dwellings and nonresidential structures built in areas that are underlain by clays or silts. Additionally, it was recommended a subsurface soils investigation be performed for any large single dwelling structure built in the collapsible silt areas (Hillside Study, p.33).

**Provo's Flood Plain**

The hillside area of Provo is not the only land problem within the city. There are also extensive flood plains found at Little Rock Canyon, Rock Canyon, Slate Canyon, Provo River and Utah Lake (See Map 3). The flood plains were mapped by the Federal Emergency
Management Agency on February 15, 1974. Zone areas were determined by the 1952 flood of Provo, which was designated as a "One Hundred Year Flood", or a flood of such magnitude that the probability of it occurring is once in one hundred years. Up until 1977, many of these lands were being developed without regard for buildings being placed in potentially dangerous locations.

**High Water Table**

Building development was occurring in sections of Provo that have a high water table. Developers were building in the areas where the water table was so high it would often "pond" during spring runoff. Or the water table would rise so high during the spring runoff it would seep through basement floors. This is what happened in the Provost School, located at 700 South State Street, and homes in the surrounding areas during the spring flood of 1983. Provost school is built over a natural artesian well. During the winter of 1983 there was a higher than normal snowfall. This caused a high runoff down Slate Canyon just east of the neighborhood being examined (Bryon, Interview). This underground water fed into the artesian well on which Provost school is built. The well became so full it
overflowed in the school basement the first week of June 1983. The city of Provo started pumping out the basement. There was so much water that one pump was not sufficient. They ended up using eight pumps. They pumped water out of the basement of the school until the end of July (Howell, Interview).

Homes located in this neighborhood had the same problem with high ground water. Many from Slate Canyon west to South State Street pumped water from their basements from the first week in June to the middle of July.

Ordinances Adopted

In 1983 the city of Provo adopted into their land use ordinance a sensitive lands ordinance that dealt with hillside development and development within the high water table area. Earlier in 1977 they had adopted a flood plain zone overlay to deal with the development within the flood plains.

The sensitive lands ordinance gave the city power to impose certain requirements upon developers to insure development sites would not have negative effects upon the land being used or the structures thereon.
The hillside development standards were incorporated into the subdivision regulations. There were ten policies that attempted to achieve successful hillside subdivisions. They were:

1) Encourage only minimal grading which relates to the natural contour of the land and which will round off, in a natural manner, sharp angles at the top and ends of cut and fill slopes, and which does not result in a "stairway" or "padding" effect.

2) Require retention of trees and other vegetation which stabilize steep hillsides, retain moisture, prevent erosion, enhance the natural scenic view and, where necessary, require additional landscaping to enhance the scenic and safety qualities of the hillside.

3) Require immediate planting wherever appropriate to maintain necessary cut and fill slopes, to stabilize them with plant roots, to conceal the raw soil from view and to minimize erosion.

4) Preserve natural drainage channels.

5) Encourage retention of natural landmarks and prominent natural features, wildlife habitat and open space.

6) Preserve and enhance the visual and environmental quality through the use of natural vegetation and prohibition of excessive excavation and terracing.

7) Protect the public from natural hazards of storm water runoff and erosion by requiring drainage facilities.

8) Minimize the threat of fire damage by establishing fire protection measures.

9) Establish land use management that encourages protection of natural elements while allowing a harmonious and satisfying residential environment.

10) Encourage a regard for the view of the foothills as well as a view from the foothills (Provo City Subdivision Ordinance, pp.17-18).

The Subdivision regulations then set forth specific development standards on how the ten policies
mentioned above are to be enforced. These standards deal with grading, drainage, vegetation and revegetation, fire protection and streets.

The Sensitive Lands Ordinance also set out regulations whereby buildings can be built in the high water table area of the city, first defining where the high water table is (See map 4). The development standards are summarized below:

1) Prior to the acceptance for rezoning of property in the designated area, or before the submission of an application for preliminary subdivision in the designated area, it must be demonstrated to the satisfaction of the Community Development Director that the conditions and requirements contained in the ordinance can be met.

2) Prior to acceptance of an application for a final subdivision plat or for a mobile home plan in the specified area, it must be demonstrated to the satisfaction of the Community Development Director that all of the conditions specified in the ordinance have been fully met and accomplished.

3) Surface or sub-surface drainage from any development will not be stored on the property in any way but be transported to Utah Lake, Provo River or Provo Bay.

4) Drainage water from any proposed new development will not be placed upon or pass through other properties, except:

   a. Where a pre-existing drainage system of adequate capacity is already in use, or
   b. Where a permanent drainage easement of size sufficient to carry projected flows has been obtained and a statement from the owners of both the host and guest properties recorded on proper deeds in the office of the County Recorder specifying the following:
1) That the City will be held harmless from all damages or injury resulting from water pollution and flooding from drainage crossing said property.

2) That the property owner will allow the owner of the easement to enter onto the property to maintain the drainage facility on the easement.

3) That the drainage channel can be placed in a pipe or culvert at such time as deemed appropriate by the owner of the easement.

c. A further exception to condition number two above may be made by specific action of the Provo City Board of Commissioners when it can be demonstrated that drainage for the proposed development will be carried directly to Provo River, Provo Bay or Utah Lake in an established traditional drainage channel in which there is no water with vested irrigation rights and which has the capacity to carry projected flows.

5) Drainage from the proposed new development will not be placed in an irrigation ditch or canal except with the written permission from the irrigation company and all water users below the proposed development.

6) No building will be allowed to be constructed in a high water table area where the building includes a basement except according to the following standards:

a. Prior to the issuance of the building permit, the owner(s) produce a statement which states that the City will be held harmless from all damages of injury resulting from flooding in high water table areas.

b. Prior to issuance of any building permit with a basement, the applicant has to submit to the Chief Building Official a certificate from a registered professional engineer indicating the method or design to flood-proof the basement.
A comprehensive drainage and grading plan is to be submitted by the developer of any property within a high water table area and be approved by the City Engineer before final residential subdivision approval.

No building permit will be issued in any development in the described area until the required sub-surface and storm drainage system has been constructed and is in operable condition.

A soil test provided by a licensed soil engineer will accompany the drainage and grading plan for all areas in which underground private and public utilities will be installed. The statement must indicate what remedial action will be taken to stabilize utility lines to assure they do not shift, buckle, or lose alignment.

The above engineering plan will include a cross-section of all proposed utility trenches, showing configuration and type of materials to be used in backfill and as a "bed" for utility lines, these to be approved by the City Engineer (Sensitive Lands Development Ordinance, PP.6-10)

The flood plain zone was adopted January 16, 1979 by Provo to protect people from building in flood plains and being annually flooded. It set forth requirements to minimize development within this zone, while specifying standards for construction. These standards are summarized below:

1) Prior approval is required for development permits obtained from federal, state or local governmental agencies.

2) All proposals for construction within the flood plain area must be designed and anchored to prevent flotation, collapse or lateral movement of the structure and utilize construction methods that minimizes flood damage.

3) All proposals for construction or improvements must be provided with water supply systems or sanitary sewage systems designed to minimize or eliminate infiltration of flood waters into the
system and discharges from the system into flood water. On-site waste disposal systems must be located so as to avoid impairment of, or contamination from these systems during flooding.

4) No structure, earthfill or other surface obstruction to water, except bridges or flood control devices, and no parking lot in connection with any industrial, commercial, or multiple residential development, will be allowed to be located closer than one hundred feet to the bank of Provo River, or within a designated water passage area within the established flood plain.

5) Any enroachments such as fill, new construction, substantial improvements, and other development within the regulatory floodway resulting in any increase in flood levels within Provo during the occurrence of the base flood discharge are prohibited.

6) The buildings will be constructed and placed on the building site so as to offer the minimum obstruction to the flood or flood waters. Whenever possible, buildings or structures will be constructed with longitudinal axis parallel to the direction of flood flow. So far as is practical, buildings or structures will be placed approximately on the same flood flow lines as those of adjoining structures.

7) Location of any structural storage facilities for chemicals, explosives, buoyant materials, flammable liquids, or other toxic materials which could be hazardous to public health, safety and welfare will be floodproofed to prevent flotation of storage containers, or damage to storage containers which could result in the escape of toxic materials into flood waters.

8) A statement describing the elevation (in relation to mean sea level) of the lowest habitable floor (including basement) of all new or substantially improved structures, and whether or not such structures contain a basement, will be submitted to the Community Development Director, or his Designee.

9) Adjacent communities and the State Coordinating Office must be notified prior to any alteration or relocation of a water course, and copies of such notifications must be submitted to the FIA Administrator.
By the end of 1981 all of the sensitive lands within the city limits of Provo had been put under protective ordinances. All new developments are subject to these ordinances. They are designed to protect both the land and people from harm.
CHAPTER IV

Development of Provo's Sensitive Lands

When Provo was settled by the Mormons in 1849 they located their fort and homes near the mouth of the Provo River at approximately Geneva Road and 300 North. The river was essential for farms and water. However, in the spring of 1850, dampness, mud and malaria forced the settlers to move inland and resettle in the area of North Park, in what became downtown Provo (Provo River and Rock Canyon Creek Study, p.1).

In the next one hundred years, the city of Provo developed outward in a four-block radius from Center Street and University Avenue. The rest of the area was farm land, with a single family home per farm.

Hillside Development

The earliest record of hillside development dates from 1954 with a request to the Planning Commission for preliminary development of the Oak Hills subdivision. The records show the only concern of the Planning Commission at that time was the 11% grade at Oak Lane which, they felt, could cause some problems during winter (See Map 5).
In 1955 the Sagewood Heights subdivision was proposed to be developed next to Oak Hills. This created a problem because the Oak Lane grade would have to be changed to 15.5% if aligned with Sagewood Heights. Final approval for the first Oak Hills plat was granted in 1959.

This subdivision continued to grow for the next twenty years. As various plats of this development were reviewed by the Planning Commission, there was concern regarding the problems the subdivision might create by moving up the hill. For instance, on April 9, 1969 Plat H was approved on conditions the developers provided sidewalk and street improvements and solve the drainage problems created by the plat. A drainage system was needed to carry the run-off down the hill without harming the property below them.

In 1975 the Oak Hill developers presented plat K, located between 1450 and 1500 East, for approval. It had several problems. First was the proposed alignment of 1500 North between 1450 and 1500 East. In preliminary discussions between the Planning staff and the developers the staff was assured this street would not exceed a 15% grade. However, the grade was approximately 22%, making the road too steep to be
traveled in winter. The street had to be reconfigured taking into account the natural topography of the area.

Another problem was drainage. Until the developers could construct a system acceptable to the City Engineering department they would not be granted final approval.

On June 8, 1976 final approval for this plat was granted but with two stipulations:

1) Street grades could not exceed 15%, and
2) The curb had to be enlarged and french drains provided on one side of 1450 East.

On January 10, 1977 a temporary moratorium was placed on all new building above the 5200-foot elevation since the city was having difficulty servicing these areas. Merrill Bingham, Director of the Water and Waste Water department, explained the moratorium was adopted because the elevation of the Provo water tank is 5390 feet, and homes above the 5200 foot level would not receive sufficient water pressure. There was also the problem of getting the garbage truck, snow plows and emergency vehicles into these elevated areas.

At the same time the Community Development Department was concerned with the stability of the soil and hillsides and were conducting a study to determine
the best approach to controlling damaging hillside development. This was another factor which caused the moratorium to be enacted. The moratorium was lifted after the hillside study was completed.

During this time the developers of Oak Hills submitted another plat for approval, Plat M. This was above the 5200 foot level, causing serious water problems for this area. During the summer at peak usage hours pressure would drop to zero. This not only annoyed homeowners but created a potential fire hazard because of the lack of water to the fire hydrants.

Lot layout was also a concern. The topography was extremely steep and required excessive cutting and filling to establish buildable areas for homes. The planning staff was apprehensive of how this cutting and filling would affect the stability of the mountain side since investigation indicated the presence of an old landslide in the area. If the lots were cut poorly, the mountain could give way and damage the homes below. Plat M was denied building approval because of these topographical problems.

The next plat the developers brought in, Plat N, was denied for similar reasons. Six lots were too steep to build on and were removed from the plans. The
developer withdrew the entire plat rather than give up these six lots. This was the last subdivision plat presented by the Oak Hills developers.

The hillside study revealed several facts about the land on which the Oak Hills subdivision is build.

First, the only area that has a grade of less than 14% is Oak Lane from 1220 East to just below 1850 North. East and West of Oak Lane the slope increases to 15-30%, and North Oak Lane and Oakcrest are above 30% grade.

Second, there is a landslide and active fault line in the area. Development of this site could undermine the stability of the mountain, causing it to give way.

Another subdivision developed about the same time as Oak Hills was the Indian Hills Subdivision (See Map 6). The first subdivision plat, Plat A, was recorded and accepted by Provo City on June 4, 1958, while the last was accepted on May 25, 1982. Except for the last few subdivision plats there are no records of the Planning Commission approving or denying the plats. Available records do not express concerns with the proposed land uses.
INDIAN BILLS SUBDIVISION

Map 6
The next hillside subdivision was Cascade Mountain Estates, 4380 North 650 East (See Map 7). This subdivision had to provide water courses or drainage ditches and streets within established grades before it passed inspection.*

The reasons these standards were imposed on this development is due to land structure. East of the intersection 4380 North 650 East the land slope is PmnO which means it is less suitable for construction.** The land is easily disturbed and a potential hazard if not properly developed. Streets that are too steep or have excessive water runoff cause the land to wash or slide away. So far there has not been any earth movements in this area.

One of the largest hillside subdivisions in Provo is Quail Valley, located north and east of Timpanogos High School. It is comprised of Quail Valley Drive and several cul-de-sacs including North Little Rock Drive West, East Little Rock Drive, Quail Run, Quail Ridge and Quail Summit (See Map 8). None of this land is less than 15% grade, while much of it is above 30%.

*The established grades were not available but it is probable that they were similar to the acceptable grades of Oak Hills.
**See Appendix 1 for the definitions of symbols.
Map 7
The soil construction suitability for this area is as follows:

- Quail Valley Drive—Standard for construction
- Quail Run—Marginal
- Quail Ridge—Marginal
- Quail Summit—Marginal-Hazardous
- North Little Rock West—Marginal
- East Little Rock Drive—Hazardous

Not only is most of the land steep and questionable in its ability to support buildings, but there is an active fault line through the middle of this subdivision. These factors add up to a greater probability of danger than in many of the subdivisions in the valley below.

Quail Valley development began in 1973. During March of that year, the first plat of this subdivision, the Villages of Quail Valley Plat A, was approved. During the next three to four years bits and pieces were added until today the "Villages" are completely built up. However, during the time they were being developed the Sensitive Lands Ordinance had not been accepted as an official city ordinance. Therefore, the city of Provo was not able to put strict regulations on the different plats of Quail Valley in order to insure it was developed in a safe manner. In the final approval the only record of conditions imposed is for
Plat B, found approximately at Indian Hills Drive and Quail Valley Drive, given July 9, 1975. It states that:

1) No parking signs be posted on one side of the lane.
2) Fire hydrants be placed along the land and approved by the Fire Department.

Nevertheless, many of the City Departments recognized the severe problems and difficult issues that arose with this subdivision. During 1974 when the Villages of Quail Valley were expanding, the planning staff noted that there was not enough steps taken to comply with even preliminary storm drainage control. This was a serious problem because the bulk of the "Villages" are built in the middle of Little Rock Flood Plain. This problem was compounded by the development of the Sherwood Hills area just north of Quail Valley. The storm drains and retention basins of this development had not been built and runoff from Sherwood Hills would flow down the roads to Quail Valley and increase the flooding of that area. The staff recommended that expansion for the "Villages" be held up until the developers were able to work out a storm drainage system acceptable to City Engineers. This recommendation was accepted by the Planning Commission
and in 1976 final approval was not granted until the storm drain problem was solved to the satisfaction of the Engineers.

Most of the plats submitted for approval had storm drainage problems. The owner of lot 37 Plat C wrote to the city about his concern over the storm drain behind his property. Jack Zirbes, City Engineer replied:

This is a major storm drain outlet draining the Little Rock Canyon area immediately east of this development. A retention basin has been constructed above your property that protects the downstream owner to a degree; however, the developer will be required to relocate any existing drainage canals on lots that would ultimately be constructed on if that construction interferes with the canal. I would suggest that you take very serious consideration to having the house constructed high enough and take some landscaping and drainage considerations to protect your home in the event that the canal would overflow in that area. The drainage canal will have to be protected either by piping or keeping the open canal in the area of your property (Quail Valley Files Plat C).

Despite the problems with drainage from Little Rock Canyon and the slope, this area continued to be developed. However, the Planning staff and Commission grew stricter in what was acceptable for development. For instance, on September 8, 1976 plans for Quail Summit were presented to the Planning Commission for approval. Because of the steepness and the location of
the lots on this plat the Fire Department was concerned they would not be able to get to the area in time to control a fire. So the Planning Commission imposed additional conditions upon the developers including:

1) Homes constructed in this area be sprinkled for fire protection.
2) A thirty-foot landscaping buffer be provided around homes to prevent the spreading of fire.
3) Nonflammable roofs and exterior siding be provided on all homes built in this area to minimize fire danger.

Final approval was given November 10, 1976, with additional conditions attached. Two of them dealt directly with the fact that the area was in a sensitive lands area. There was a stipulation that approval of the first six lots would not be given until an acceptable grade was provided by combining lots 7 and 8. Also, a drainage plan for this phase of the development was needed, with overall final plans prepared and presented for review and approval by the City Engineers.

After the plat was approved and construction began, some of the hillside development problems became realities. On November 29, 1977 Jack Zirbes, City Engineer, wrote a letter to the developers concerning problems they were causing the homeowners in the cul-de-sacs below:
Quail Summit Subdivision is causing some serious drainage problems to the homeowners in the cul-de-sacs below this development...In my opinion, it is critical that a catch basin be constructed at the end of the cul-de-sac [Quail Summit] to pick up the drainage water and take it in a pipe down the hill and into the outfall canal at the base of the hill. If this is not done, the erosion conditions that have started will continue and ultimately there will be a failure in this road and possibly some severe damages caused to the homeowners and lot owners in the cul-de-sacs below. I also observed, while investigating this area in the field, that the drainage outlet structure at the one cul-de-sac has not been completed. It has silted up with mud and debris, the grate that was to be used over this outlet structure does not fit and is laying along the canal (Quail Valley Files, Quail Summit Plat).

In a followup letter Mr. Zirbes again expressed concern over this situation. He was worried about water run-off sheeting out of the cul-de-sac onto the Quail Summit Drive. Mr. Zirbes suggested this problem be solved with either an increased rise of asphalt at the entrance of the private street or with a crossgutter type of constructon in the cul-de-sac. Either would help prevent water from going into Quail Summit Drive.

Another problem surfaced because of the slope of one of the streets. Dave Gardner, Zoning Administrator, wrote to the developers warning them that Quail Summit Drive had the definite potential of being a hazardous street during the winter. The road is on a slight grade of approximately 10%, and on the
northwest side of the road is a steep embankment. If the road became icy during a snow storm, there was the potential of someone sliding off the road and into a ravine below. It was suggested that guard rails be placed on the northwest side of the road to provide some measure of safety (Quail Valley Files, Quail Summit Plat). This advice was complied with.

One of the most difficult subdivisions for the planning staff to work with has been the Sherwood Hills Subdivision. This development is located north and east of Quail Valley, which means all of the plats are located on the hillside.

The slope in this area is above 15%. Five of the major streets--Wimbledon, Winston, Norfolk, Bedford and Devonshire--are in the range from 15-30%, while Mile High Drive and all of Sherwood Hills above Devonshire, are above 30% (See Map 9). The steepness of the slope created the potential for erosion and earth movements as the developer removed the natural vegetation to cut and fill each lot to create building pads for home construction.

Compounding this problem is the geological structure of the mountainside itself. It is PMmc which means it is "less suitable" for building. There is a
well exposed fault line running through the top of the subdivision and the soils are of standard building suitability only in the 15-30% slope range. Therefore, it has greater potential for creating destructive situations during the spring and winter storms.

Another problem in the Sherwood Hills subdivision and others nearby is the inability of the city to provide the proper services in these areas, such as water and fire protection. Much of these subdivisions are above the 5300 foot water tank and water pressure is not strong enough to get water to the homes and hydrants in the area.

The Department of Water & Waste Water hired Thurgood and Associates, Incorporated to do a study on the water situation in these areas. These engineers studied the demands for water and how to meet them. They also determined the water use requirements of the area. Their findings are as follows:

Per Capita Requirement

<table>
<thead>
<tr>
<th>Requirement</th>
<th>GPD (Gallons per day)</th>
<th>GPM (Gallons per Minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Day</td>
<td>320</td>
<td>0.22</td>
</tr>
<tr>
<td>Maximum Day</td>
<td>672</td>
<td>0.47</td>
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<tr>
<td>Peak Hourly</td>
<td>1129</td>
<td>0.78</td>
</tr>
<tr>
<td>Fireflow</td>
<td></td>
<td>2000</td>
</tr>
</tbody>
</table>
If a unit density of four people per unit were assumed for this area the total anticipated population for the Sherwood Hills Plats E, F and G above the 5300 elevation mark would be 428 persons. If this were multiplied to the above table the total water requirement would be as follows:

Total Water Requirement

<table>
<thead>
<tr>
<th></th>
<th>GPD</th>
<th>GPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Day</td>
<td>136,960</td>
<td>95.1</td>
</tr>
<tr>
<td>Maximum Day</td>
<td>287,616</td>
<td>199.7</td>
</tr>
<tr>
<td>Peak Hourly</td>
<td>483,194</td>
<td>335.51</td>
</tr>
<tr>
<td>Fireflow</td>
<td>2000</td>
<td></td>
</tr>
</tbody>
</table>

The only way that water can be provided in this volume is to install a booster pump station to pump water out of the existing northeast water zone. In order to accommodate the needs of this area the booster station would have to be equipped with at least two pumps that are capable of producing the daily maximum flow, which is 200 gallons per minute. This flow rate would require that a water storage reservoir be constructed to provide water for peak hourly fluctuations and also to meet the fireflow needs (Sherwood Hills Files, Plat G).

Fire is a concern of the city and the United States Forest Service. Behind the Sherwood Hills
subdivision is natural vegetation. If a fire broke out on the hills there would have to be an access to the fire for the fire department to use.

Wildfire is not the only fire hazard in the area. The Fire department response time would be longer due to having to maneuver on such steep roads.

Development of Sherwood Hills began in the early 1970's. The only records kept of the first two plats were that they were approved. However, beginning with the third plat certain conditions were set before approval could be given. The Planning Commission ruled that:

1) A detailed drainage plan be presented to the city engineer for his approval before the plat is taken to the City Commission.

2) That additional auxiliary control valves, gate valves, and fire hydrants be provided as required by the director of Water and Waste Water.

3) That lots 117, 102, 77, 83, 82 and 81 be enlarged or setback variances be received on these lots in order to place residences comparable to existing homes in the area. (If the variances are needed, this should be the responsibility of the developer and not individual property owners when these lots are sold.)

The Planning Commission ordered any lots that may fall into the categories of requiring variances be presented to and approved by the Board of Adjustments
prior to requesting signatures on the plat. The final approval for the third (Plat C) was given October 13, 1976.

When Plat D was presented the staff did not find or see any problems with the design; therefore, the Planning Commission passed and approved Plat D, March 9, 1977 without any conditions attached.

The rest of the plats had greater restrictions, which restrictions proved beneficial as time went on.

Plat E had to get approval from Utah Power and Light showing lots 157-160 were set back far enough from the power lines before building permits would be issued. A storm drainage system had to approved by the city engineer, and approximately eight acres of land were to be used for a retention basin.

Plat H was accepted on the conditions that all slopes be dressed to a ratio of 1 1/2 to 1, and all fill at a ratio of 2 to 1. This means that for every foot and a half of earth cut into the mountain, the developers could go up the mountain one foot. And for every two feet of earth added to fill the mountain it could only drop one foot.

In 1978 Plat G was presented for approval. This plat turned out to be biggest problem of all. Over 50%
of the plat consisted of property in excess of a 25% slope. In order to establish roads at a 15% or lower grade some of the areas had to be cut up to 15 feet. Many lots would require further grading to gain access.

The amount of cutting and filling made it imperative the soil be compacted properly. Improper soil compaction had already caused street improvements to fail and had been responsible for damage to several structures in the Sherwood Hills subdivision (Sherwood Hills File, Plat G).

In addition the amount of grading would destroy vegetation cover and the character of the hillside. This would lead to increased erosion. Because of the removal of vegetation and the change of the slope character, the drainage pattern would be changed, which would result in a higher rate of erosion and potential soil instability.

Plat G also presented a problem in fire protection for the entire city for Provo. There was no way the firefighters could get behind the subdivision to fight fires because the plat did not include a back access to the hills.
These were the major problems with this subdivision. It was approved on August 9, 1978 with strict conditions. These were:

1) All applicable standards of the hillside provisions of the subdivision ordinance must be adhered to with the exception of sections 15.16.020.1 c and d. A variance to these standards can be given only by the City Commission.

Sections 15.16.020.1 c and d deals with the percentage of ground needed to obtain a building permit, and the material to be used in fills and compaction.

2) All documents listed in section 15.12.020 be submitted with the final plat and that the plat not be recorded until such documents have been received. Submission of these documents will aid enforcement personnel in seeing that the subdivision is constructed as approved.

   a. Drawings showing layout, profile and detail design for sewer lines, water lines, and storm drains.

   b. Plan profile and typical cross section drawings of streets, bridges, culverts, and other drainage structures.

   c. Final grading and drainage plan to the satisfaction of the city engineer indicating the finished grade by solid line contours superimposed on dashed line contours indicating existing topography of the entire plat. Such contours shall be at five feet intervals.

   d. Vegetation plan to the satisfaction of the city engineer and zoning administrator showing existing vegetation to remain and the size, type, and location of vegetation to be replaced.

   e. Erosion control plan to the satisfaction of the city engineer.

   f. Fully executed subdivision improvements agreement on a form furnished by the office of the city engineer.
3) That as part of the vegetation plan required by #2 above, a time table for incremental revegetation of all areas graded by the subdivider be agreed upon to the satisfaction of the Community Developer director.

4) That all lots be flagged in accordance with recently adopted enforcement procedures, as outlined in the appendix, to insure proper grading techniques on individual lots once they are purchased by individuals.

5) That the design of the auxiliary water system shall receive written approval from the Water and Waste Water director prior to the signing of the final plat by the city commission.

6) That the design of access easements for fire fighting and prevention receive written approval from the fire chief prior to the signing of the subdivision plat by the city commission. Easements are to be found on lots 304, 315, and 322, and vehicle access of the south end.

7) That all fill areas be placed in lifts not to exceed two feet and that each lift be compacted to 95% density certified to the city engineer by the project engineer. Standard by ordinance.

8) That a bond be issued for a period of five years to cover the costs of and improvements which may fail during that period. The amount of this bond being established by the city commission (Sherwood Hills File, Plat G).

Even with these conditions a city is not necessarily assured a developer will do what is required. Therefore, a city makes the developer bond so much money—or land to the city to insure the requirements are met. When the developer fulfills his obligation, the city releases his bond.

With Sherwood Hills Plat G, the developer was required to bond for the street improvements and
reseeding. On December 2, 1981 Steve Scheiss, Zoning Enforcer, stated in a letter to Jack Zirbes:

A reseeding plan was submitted to, and approved by, our office which showed those slopes which needed to be reseeded as the result of grading for the proposed subdivision. At the present time, the majority of these slopes remain bare. Reseeding, in my opinion, means not only that grass seed has been planted, but also that it is up and growing.

Until such time as grass is up and growing on all cut and fill slopes as required by the Subdivision Ordinance the bond for reseeding could not be released. This was three years after approval had been given for the development of Plat G.

Not only were there problems with reseeding, but there was illegal building going on at the same time. On October 20, 1978 Commissioner J. Wignall was notified by Nicholas R. Jones, Field Engineer for Provo about some of the problems with this subdivision. The street compaction tests taken of Victoria Circle and Bristol Circle failed to reach the set standards. The material seemed to be just pushed in by the work crews, and was not compacted properly before the concrete curb and gutters were poured. These actions were done without the necessary permits from the engineering department. The developers Steven Stewart and Thorn Construction were notified not to pave before the fill
had been compacted but went ahead and had the work done, leaving unstable improvements which the city feared would eventually sink. Therefore, the city held the improvements bond until the improvements had a sufficient time to sink and be replaced (Sherwood Hills File, Plat G).

This same type of hillside construction continued through the year. In December 1978, it was reported by Neil Lindberg, City Planner, that the storm drainage easement, a natural gully, was being filled with earth. According to the grading plan this easement was to remain in its natural state. To fill it was a breach of law and caused a hazardous situation because with the easement filled there would not be a channel for the water to follow. Thus it would be diverted and create erosion problems.

Despite the conditions put on the development of Sherwood Hills there have been problems since its construction. These are the same as other hillside developments: erosion, soil settling--damaging the structures on top--and drainage of the water run-off. Often times these problems are a result of poor
development with developers who do not do take precautions and try to eliminate the problems before they start.

There are several ways that these problems can be overcome. First the city could include in its Subdivision Ordinance under Hillside Development 15.16, that all hillside developments must be bonded for improvements. The bonds will be held for five years to allow for settling or other problems to occur and be corrected.

Along with the five-year bond, if the developers were to build on the hillside without complying to the hillside standards the city would automatically hold the bond for an extra two years to make sure that any subsequent problems are corrected by the developer and not the city. This time lapse would help the city avoid extra expense in maintaining the hillside subdivisions.

The city could also refuse a certificate of occupancy to the developer if the developer ignores the hillside building standards. Without this certificate of occupancy, a building cannot to be occupied. Therefore, a developer would not be able to fill his units, and his entire development would be an expensive waste.
If these two ideas became part of the subdivision regulations, they would help enforce the hillside standards because it would be easier and more profitable for the developer to comply with the set standards instead of ignoring them. This compliance would help elimate some of the problems involved in hillside development.

Development of the Flood Plain

Provo City has four distinct flood plains. They are the area extending the course of Provo River to Utah Lake, including the lake, and the ones emerging from Little Rock Canyon, Rock Canyon and Slate Canyon.

Although the bulk of the population was clustered around Center and University from 1848 to approximately 1948, subdivision and private individual developments began along the river long before that. During the 1800's the river was an important place for feeding livestock, as well as obtain food and water for family and farm (Study of the Lower Provo River, pp.41-46). But by 1944 the first subdivision, Riverside, was laid out along the river. It is located along 800 North and 700 West (See Map 10). When it was developed there were no laws to prohibit lots from extending right to the river banks. Developers were not required to set
the homes back to insure they were out of the flood plain. As a result this subdivision is threatened by every Provo River flood.

Development of homes in this area was slow. It was not until the late 1960's that subdivisions started going in along the river at a fast rate. On September 10, 1969 the Country Club Estates, at 2230 North, 300 West went in (See Map 11). Again, there were no restrictions.

In 1974 it was proposed a parcel of property found along 3000 North Carterville Road be annexed. The engineering company Rollings, Brown, and Gunnell, Inc. found the property was not in a flood plain. However, a letter from Dennis Sykes to the city of Provo claimed it was, and "the city should be careful" in how they zoned it.

According to Richard Hope and Mr. and Mrs. John Emmons, long-time residents of the area, the area of the proposed development had, indeed, been flooded various times over the past years, including during Provo River floods in the early 1950's after the Deer Creek Dam was built" (Three Fountains File).

The city council went ahead and annexed the parcel. This parcel then became an addition to the Three Fountains subdivision (See Map 12).
Map 11
By 1977 the Flood Plain Ordinance was being adopted and enforced. The ordinance required all lots be set back 100 feet from the river. On July 13, 1977 the Subdivision River Grove at 680 North 100 West was presented for approval (See Map 13). It was granted under condition that all lots be brought under compliance with the new setback rule or a variance to the rule be obtained from the Board of Adjustment. A detailed drainage plan had to be submitted in order to insure storm water was going into the river and not into the streets. The final approval was granted September 14, 1977.

Manorly Court, 1200 South 600 West, was another subdivision developed in 1977 (See Map 14). They were required to elevate the building sites above the flood plain level, as determined by the city engineer. In the past, all door and window openings were required to be elevated two feet above the road. Now it is required the doors be built above the expectation of the water levels of a one hundred year flood, whatever that level may be (Manorly Courts File).

One of the earliest subdivisions that was built under the new flood plain ordinance was Riverwood Estates, 3700 North 400 West (See Map 15). This
subdivision had a different problem than the foothills since the land was so level and low the homes were below the flood level. Therefore, an environmental impact statement had to be given by the developers, stating how they would make sure their development would not greatly damage the environment. The statement was as follows:

1) Erosion control in the subdivision area will be accomplished through planting and seeding by the individual property owners. The terrain is generally flat and runoff will be confined to paved and guttered streets.

2) Reseeding of cuts and fills will be limited to the immediate vicinity of specific street sections, will be limited to approximately two feet in elevation difference, and will be performed by the individual property owners.

3) No significant geologic hazards of injurious soil conditions which may cause injury or damage exist, with the exception of the entrance way on the southwest corner of the subdivision. A cooperative program between the developers and Provo City to improve the approachway and foliage-related sight distance problems at the point will be required.

4) Fire prevention and dust control are not considered to be a problem as the Provo River is easily accessible and a minimum of earth work will be required.

5) Prevention of the accumulation of weeds and debris will be the responsibility of the individual property owners and will be monitored during construction.

6) Prevention of the destruction of vegetation will be accomplished by the preservation of all trees, etc. that are not in conflict with the development improvements, i.e. roads, curb and gutter, and sidewalks, and which do not pose a safety hazard.
7) Disposal of surface water and side position of flood water will be accomplished using the gutter and roadway system as the primary runoff network, terminating in a piped disposal line to the Provo River as shown on the plans and approved by Provo City (Riverwood Estates File).

Approval was given for Riverwood Estates on condition that there was an adequate drainage system to prevent erosion and flooding, and lots provided enough depth so any structures built were located one hundred feet from the river.

Rock Canyon Flood Plain

The Rock Canyon Creek drains out of Rock Canyon to the debris basin behind 1200 East Street, north to 2620 North street, then west along 2920 past Rock Canyon Drive to the Denver and Rio Grande Western Railroad, south along the railroad to 2230 North where it turns west and meets the Provo River in the middle of the Riverside Country Club. The flood plain follows the same basic route, except over a broader area (See Map 3). Most of the subdivisions in this area have already been discussed under "Hillside Development."

Another development found in the middle of this flood plain is the subdivision of 1200 East North Temple Drive (See Map 16). Because of the location within the flood zone, the Planning staff felt nine-inch curb and
gutters should be provided. Also, there should be adequate grading on each lot to insure that all openings into a house were at least two feet above the curb. The Planning Commission agreed with the staff and conditionally approved the subdivision on those conditions plus some others, i.e., all lots receive a conditional use permit for homes constructed in the flood plain, and that the original plat of the subdivision indicate that all lots are in the flood plain.

**Slate Canyon Flood Plain**

Slate Canyon Creek flows out of Slate Canyon into a debris basin where it is channeled into irrigation canals and used by the residents of southeast Provo. The flood plain follows the same course as the canyon, then spreads north along the foothills to the mental hospital, and west along 100, 200, 300 and 400 South streets (See Map 3).

Flooding from Slate Canyon does not usually occur from snowmelt. Instead, it results from high intensity, convective-type thunderstorms centered over the tributary area. These storms, which may be of any duration, usually happen between May and September, with the most frequent times being July and August.
The intensity is high and the resulting runoff characterized by a high peak flow of short duration and small volume. Even though the volume tends to be low, the drainage basin of Slate Canyon Creek is small, and a thunderstorm could cover the drainage basin and flood the entire area (Provo River-Slate Canyon Flood Study, p.4).

The development of this flood plain occurred fairly early as compared to the other flood plains. There are three subdivisions in this plain: East Park Addition, Wasatch Gardens, and Utah Valley Subdivision.

East Park Addition is located between Center Street and 200 South, and 700 East to 900 East (See Map 17). It was approved for development by the City Commission September 19, 1923.

Wasatch Gardens is located along 400 South from 900 East to Utah Avenue (See Map 18). It was approved for development May 13, 1943.

Utah Valley Subdivision is located between 200 to 300 South and 1060 to 1200 East (See Map 18). This subdivision was approved May 12, 1943. All of these subdivisions were approved before any type of flood proof measures were required of the developers.
High Water Table

Closely interwoven with the flood plains in Provo is the high water table area. This area starts at approximately Billings Avenue on South State street, moving north along University to Orem, then southwest along the Grandview bench out to Utah Lake, then along the shoreline and back to Billings Avenue (See Map 4).

One of the subdivisions that came before the Planning Commission for approval was Harbor Park, 650 North Geneva Road and Boat Harbor Drive (See Map 19). The first plat, Plat A, was approved February 9, 1977 on condition that a detailed drainage plan be submitted to the city engineer. Plats B, C and D were approved with basically the same condition. It was not long before problems developed in the subdivision. Twice in October of 1978, the Department of Water and Waste Water, and the Waste Water Collection Division, had to seal up leaks in the new sewer lines at Harbor Park. There was natural groundwater leaking into the system. Cost to repair these leaks was $4,697.36.

Mrs. Kathy Froerer wrote to the city and asked for a solution to her foundation leakage problems. Nicholas Jones, Assistant Engineer, replied that foundations will not prevent water from leaking through small cracks and
the only effective solution was to eliminate the water from around the foundation. Mr. Nicholas suggested:

We have found that a perforated drain located six inches below the footing on the outside of the building running to a manhole or sump where it may be pumped, in most cases will prevent foundation leakage by removing the water before it can cause a problem. A perforated four inch pipe is normally adequate to draw down ground water or surface around the foundation. This pipe should be backfilled with granular material all the way to the surface of the ground to guarantee interception of the water. In many cases we have seen this foundation drainage system installed five feet outside of the footing which prevents footing erosion, which might occur (Harbor Park File).

The subdivision of Harbor Park continued to have problems with groundwater leaking into the sewer system, even though the sewer lines were tight and had been accepted by the city. On March 18, 1981 Steve Schiess, Zoning Enforcer, was directed to release the bonds of Harbor Park despite the groundwater problem because the developer had done his work and put in sealed sewer lines.

Other subdivisions went in on the high groundwater areas i.e., Lakewood, Lakeview, etc. All structures built over the high water table face the same problem of water seepage into their homes during springs with high runoff.
**Flood History**


There are not any records of Little Rock Canyon flooding before 1983.

Rock Canyon had flooding in 1849, 1896, 1905, 1920, 1913, 1920, 1925, 1927, 1936, 1952, 1963 and 1983 (Provo River and Rock Canyon Creek Study, p.4). However, because of the nature of the documentary evidence and the absence of stream flow records, information on the magnitude of flooding and flood damage is essentially nonexistent.

Slate Canyon had flooding on the outwash fan in 1920, 1936 and 1983 (Provo River and Slate Canyon Creek Study, p.4). Here also information on the magnitude of flooding and flood damage is minimal.

The two largest floods in the history of Provo have been in 1952 and 1983. The 1983 flood has been the biggest in magnitude because it involved all of the flood plains. The winter of 1982-1983 had an unusually high rate of snowfall which meant the snowmelt would be
above average and there would be flooding. Aware of this fact, the city of Provo started in October 1982 to prepare and prevent the most severe damage.

By February Utah Lake had risen high enough above compromise that the city was granted $750,000 to have the Army Corps of Engineers construct dikes around the Municipal Airport. Dikes were built because land in this area is lower than compromise* (Provo Flood Information Newsletter, P.1).

Bad weather continued throughout April and into the first of May. However, by May 22 the weather turned hot. For over a week temperatures were in the high 80's and 90's. This melted the snowpack faster than normal. By the 26th there was so much water coming out of Little Rock Canyon, Rock Canyon, and Slate Canyon that homes built in these flood plains were facing danger. The hot weather continued and by Saturday May 27, 1983 the subdivisions along Provo River were threatened by the river overflowing its banks. For the next three weeks city employees worked

*Compromise level is an elevation set by law to which Utah Lake is allowed to rise unimpeded. After which the diversion dam must be opened to allow the excess water to flow out of the lake into the Jordan River. This elevation is 4489.34 feet above sea level.
around the clock, pouring cement blocks* into the river to try to stabilize the banks, diking and sandbagging the river and homes, digging channels in the canyons to drain the water down sandbagged streets—anything to divert it away from endangered homes. The worry was that the snowmelt from the nearby Wasatch Mountains would not be gone before the snowpack in the High Uinta's melted and added more water to Deer Creek Reservoir than the reservoir could contain. If that happened, water would flow over the spillway into the Provo River. The river was already running between 1700 and 2000 cubic feet of water per second, and any excess water would make the river uncontrollable and the city would not be able to strengthen the banks enough to stop them from giving away. Fortunately, the canyon river dried out somewhat before the runoff came from the Uinta's. The weather also cooled several degrees, which slowed the rate of snowmelt, thereby slowing the runoff rate into the river.

The city of Provo was able to contain the flood and prevent any home damage but at a high cost. The estimate is that nine tons of sand was used for sandbags, while approximately 43,000 manhours were used

*This process is commonly known as rip-rapping.
used in three weeks of work. The estimated cost of the entire flood effort is $2,000,000* (Mickelsen, Interview).

Even though no homes were damaged not all homes and buildings in the sensitive lands area came out of the flood unscathed. The biggest problem was high water seepage. Many homes had water seeping into their basements and were pumping it out at a rate of 8000 to 40,000 gallons per hour (Harding, Interview). Most of these were in known areas of high ground water, such as homes off South State street or in the Lakewood area. Some homes had water seepage because they were located along the river, and there was so much water flowing down the river the ground became saturated and excess water forced itself up through the foundations of structures.

Flooding was severe because all potential flood areas flooded at the same time. The canyons, river and lake increased in water volume within two days of each other. The sobering thought is that Utah Lake rose five feet above compromise, and is not expected to retreat to compromise before the winter storms of 1983-1984 begin.

*These are estimates because Provo has not finished with all of the flood clean up.
If this happens, even with a mild winter the city of Provo will already have a high water lake flooding problem before the annual spring runoff starts.
CHAPTER V

Summary and Conclusion

Provo chose to develop a Sensitive Lands Ordinance and Flood Plain Zone because the city was growing at a rapid rate. Subdivisions and buildings were going up in areas that were previously not used. The government felt that certain measures needed to be taken to insure the land was not needlessly destroyed and peoples' lives and property were protected as much as possible.

Nevertheless, there has been some problems with these ordinances. One involves timing, i.e., the ordinances were adopted late in the development of some of the most critical areas. Much of the hillside of North Provo had been developed before a hillside study was done. This same thing happened along the river-banks. One area not completely developed is the high water table area. However, the land west of Interstate 15 is expected to develop in the future as Provo grows. This land faces two problems: high ground water and being in a flood plain.

Another problem inherent in Sensitive Lands regulations is enforcement. If a person deliberatly
ignores city regulations and ordinances, the only recourse the city can take is to press charges. The charge is a criminal charge and if a person is found guilty he can be fined up to $49 per day that the violation continues and/or imprisoned up to 30 days for each violation. He also has a misdemeanor put on his record. In Provo, the largest fine for a development oriented misdemeanor conviction is $200, and it is not even known if that fine was paid or suspended. The fine does not cover the cost of the zoning enforcer going to court to testify, let alone the city attorney presenting his case (Harding, Interview).

However, people are hurt by developers who know they can ignore building regulations. It is usually the third party or buyer who gets hurt. They buy a home not knowing they are not set far enough from the river that, given a flood, the ground floor of their home could be inundated. Or that the ground their home is built upon is subject to groundwater seepage. How is this problem to be solved? Most people, when they build or buy a home, do not go into the city planning office to find out if the land they are purchasing has any problems. Then, when there are problems, they expect the city to solve them. Is it the city's
involved in real estate actions, instead of providing services to the citizens of the city? These are some of the issues that are raised if the city tries to inform people of everything they need to know about buying and owning land.

If, however, it is not the role of the city to insure that people are not taken advantage of by developers who are not concerned with potential land problems, how are people to find out about such problems? One way is through education. Basically, if the public is educated to the problems of locating within a sensitive lands area they will more likely investigate before buying. And if people choose not to locate in sensitive land areas then developers would stop building there and the city would not be facing the problem of regulation vs. denying a person's right to own, develop and sell land.

One way to educate the public is to require a course on real estate buying in high school. Land zoning and regulation and why it takes place could be taught as well as how to find out about a parcel of land, how to do a title search and how to assess property value.

This is one way to prevent the development of
sensitive lands. However, the city does have a responsibility to see that a minimum standard of safety is provided by developers.

There are several things that Provo can do. The first is to add to the Sensitive Land and Subdivision Ordinances.

When the hillside study was done in 1978, Rollins, Brown and Gunnell, Inc. suggested that certain tests and analysis be requires before development was allowed. They were: 1) A slope-stability analysis, 2) a subsurface investigation, foundation design study and earthquake analysis and 3) a subsurface soils investigation. Only the areas that met the set standards in all three tests should be allowed to be developed (Hillside study, p.33). However, the City Commission decided that to require all of these tests would be "administrative overkill," and required only the soil stability test.

Presently Provo City has contracted with another engineering group to look into the hillside problems and make additional recommendations to those of Rollins, Brown and Gunnell, Inc. Their findings and recommendations are parallel to those of the earlier engineering company (Lindburg, Interview).
Another addition to the Subdivision Ordinance should be the bonding for hillside subdivision as mentioned in Chapter IV. This process of holding a developer's bond for five to seven years if the developer ignores the building requirements could be a strong incentive to build their development correctly the first time.

With these additions, hillside development in South Provo would have less problems then the earlier ones in the north.

The Sensitive Lands Ordinance under the High Water Table could also use an amendment under item 6 which allows for basements. Because of the problem with basements flooding, it is felt that any house located in the High Water Table area should not be allowed to be built with a basement. One of the reasons for this requirement is because a person cannot receive any federal aid for groundwater flooding. And as the Flood of 1983 showed, groundwater inundating basements was the severest problem Provo had.

There are two other ways in which Provo City can try to protect their sensitive lands. The first is in the Flood Plain. Provo is now trying to obtain a 100
foot easement along both sides of Provo River (Mickelsen, Interview). This easement will give them access to the river for future flood control. At the same time it will guarantee that no one will build within one hundred feet of the river, and thus provide some measure of protection from flooding.

The final recourse Provo City has is to deny any developer who breaks the sensitive lands regulations his occupancy permit. As discussed earlier, without this permit a developer cannot let his units be occupied, and his development is worthless. If withholding the occupancy permit became an option that was used by the city, then people would hesitate to break the law concerning sensitive lands.

All of these additions and options would help to strengthen Provo City's Sensitive Lands regulations. There is a need for strong sensitive lands ordinances because land is a nonrenewable resource as well as a commodity. If land is to be preserved for the future then it must protected today.
APPENDIX I

Explanation of Geologic Symbols

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<thead>
<tr>
<th>Relatively new formations</th>
<th>Cenozoic</th>
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<tbody>
<tr>
<td></td>
<td>Quaternary</td>
</tr>
<tr>
<td></td>
<td>Qay—Relatively younger alluvial deposits</td>
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<tr>
<td></td>
<td>Qas—Alluvial surfaces</td>
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<tr>
<td></td>
<td>Qag—Colluvium and alluvium</td>
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<tr>
<td></td>
<td>Qltg—Gravelly constructional lakeshore terraces, spits and bars</td>
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<tr>
<th>Paleozoic</th>
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<tbody>
<tr>
<td>Permian/Pennsylvanian</td>
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<tr>
<td>PPo—Oquirrh formation</td>
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<tr>
<td>Pennsylvanian/Mississippian</td>
</tr>
<tr>
<td>PMmc—Manning canyon shale</td>
</tr>
<tr>
<td>Mississippian</td>
</tr>
<tr>
<td>Mgb—Great blue limestone</td>
</tr>
<tr>
<td>Mh—Humbug formation</td>
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<tr>
<td>Mun—Mississippian rocks undivided</td>
</tr>
<tr>
<td>Md—Deseret limestone</td>
</tr>
<tr>
<td>Cambrian</td>
</tr>
<tr>
<td>Cun—Cambrian rocks undivided</td>
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<tr>
<td>Ct—Tintic quartzite</td>
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<table>
<thead>
<tr>
<th>Precambrian</th>
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<tbody>
<tr>
<td>Precambrian</td>
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<tr>
<td>PCbc—Big cottonwood formation</td>
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A STUDY OF
SENSITIVE LANDS
IN PROVO

Doris R. Monson
Department of Geography
M.S. Degree, December 1983

ABSTRACT

Sensitive lands are being developed in great quantity. Because of problems caused by the development of sensitive lands, Provo City has developed land use ordinances. This thesis examines the development of Provo's ordinances along with the development of its sensitive lands. It determines ways that the city can strengthen their land use ordinances and avoid some of the problems found in sensitive land development.

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