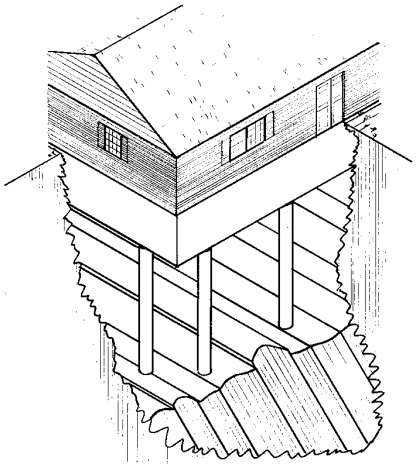
# STEEPLY DIPPING BEDROCK

**BACKGROUND**

Since the 1970s, Jefferson County has required special provisions for homes built east of the Dakota Hogback (the first row of mountains) so they could withstand the damaging effects of expansive soils. A home built on these soils generally needs a foundation that extends down into bedrock. In areas with expansive soil, slender column-like members called *drilled piers* (frequently called caissons) are typically used to found the home. These piers are anchored into bedrock, and transfer the weight of the structure to it. Additional care includes proper control of roof and surface drainage and prudent landscaping practices. For about 95 percent of these homes, extra provisions for reducing the effects of swelling soils worked well. However, in some developed areas problems continued to persist. In these areas, engineers and geologists now blame the damage on erratic movement of the bedrock.



**GEOLOGY OF DIPPING BEDROCK**

Bedrock east of the Dakota Hogback is known as Pierre Shale. Sediments deposited 80 million years ago formed it. As the Rocky Mountains pierced through the horizontal layers or *bedding planes* of Pierre Shale, they caused the bedrock to bend and dip. In some areas, bedrock planes stand nearly vertical. These severely angled planes are known as *steeply dipping bedrock*.

Geologists now theorize that development of raw land introduces moisture far into steeply dipping bedrock, which causes it to expand and move unevenly. Moisture lubricates the upturned bedrock planes, allowing them to shift under pressure. The planes behave much like a wet bar of soap when it slips upward as it is gripped tightly. Other experts suspect that bedrock planes shift because of the need to relieve stresses. In either case, the result is differential heaving (uneven lifting) of the bedrock planes and the soils above it.

**CONCERNS**

Buildings and roads built over steeply dipping bedrock are founded on the bedrock or in the soils above it. If the bedrock moves, so do the structures. The result is damage to roads and buildings of light construction. In homes, damage is typically evidenced as cracks in ceilings and walls, sloping floors, heaving concrete work, and doors and windows that bind. In severe cases, structural failure of the building's foundation can occur. Steeply dipping bedrock has been known to heave as much as two feet high in near-linear "beds" that are hundreds of feet long. The amount and location of the disruptions are sporadic. Heaving is usually detected within the first ten years after development of raw land, and can continue for decades.

In some unaffected areas, a later building addition of a nearby building development, neglect of proper irrigation and drainage practices, or a water main leak can introduce moisture that may cause previously-stable bedrock planes to heave. Once it begins, heaving will likely continue despite mitigation efforts. Compounding the situation are vast inconsistencies in where and how much the bedrock moves. Many decade-old homes have not yet experienced problems even though they are built on sites in known problematic zones. One home may not be affected while a neighboring home may experience serious structural problems. Damage is typically concentrated in small "hot" beds.

Compared to expansive soils, the behavior of steeply dipping bedrock is complex, difficult to predict with certainty, and more potentially destructive. Except in areas where movement is already apparent, the real potential for dipping bedrock destruction at a particular site can only be determined with extensive geological and geotechnical investigation.

**LOCATION**

In Colorado, steeply dipping bedrock is known to exist on the plains just east of the Front Range mountains in Douglas, El Paso, and Jefferson counties. Jefferson County has taken the lead by formally identifying potential areas of steeply dipping bedrock as a narrow ½ to 3 mile-wide belt of land directly east of the eastern slope of the Dakota Hogback. Known as the *Designated Dipping Bedrock Area* (DDBA), the zone extends from Golden north, roughly following State Highway 93. South of Golden, it follows C-470 south to the west of Chatfield Reservoir.

The DDBA contains known and suspected "hot" beds of steeply dipping bedrock where structural damage from bedrock heaving is possible. For new home construction, the DDBA regulations require engineered fill of a home's foundation bed or an alternate foundation design by a qualified professional engineer. On some potential home sites, it may be advisable not to build. Special care is also required for landscaping and maintenance of homes in this area.

The DDBA also contains areas where geological formations are more favorable for building. Favorable conditions typically exist where bedrock is covered with a thick cover of alluvial soils or engineered fill, or where non-expansive bedrock is found. Many decade-old homes have been built in the DDBA that have not yet experienced problems. However, a later increase in soil or bedrock moisture content may cause future problems to develop. The Jefferson County Planning and Zoning Department has developed a large detailed map of the DDBA. Full-size copies of this map are available at cost through this office at 303-271-8700.

**SIGNS OF HEAVING BEDROCK DAMAGE**

There are some warning signs associated with existing heaving bedrock damage that a homebuyer can look for when buying a home. These signs include:

- Differential heaving (uneven lifting) of the home, or nearby sidewalks, driveways, and streets.
- Uneven sloping of patios, porches, and floors.
- Large cracks around windows and doors, and in foundation walls.
- Doors and windows that bind.
- Evidence of repairs of severe cracks in interior drywall walls and ceilings.

These warning indicators are not an exhaustive list of telltale signs of damage related to bedrock movement. Instead, they are only possible symptoms of dipping bedrock problems. For a more accurate assessment of a home's present condition, the home buyer should have a trained professional such as a home inspector thoroughly inspect the home. However, even with a thorough inspection, later unpredictable occurrences (i.e., a nearby housing development, improper water runoff, a water main leak) can cause previously stable bedrock to begin to heave at a later time.

**FURTHER INFORMATION**

This guide was written by Joseph Wujek, a Professor of Architectural Technology at Front Range Community College, Westminster, Colorado and owner/inspector of Advanced Building Consultants, LLC, a Jefferson County home/building inspection firm. The technical content was reviewed and corroborated by a geologist from the Colorado Geological Survey. However, due to the general scope of the material presented herein versus the very complex and inconsistent behavior of steeply dipping bedrock, this document should not serve as a complete technical commentary on this issue.

A qualified home/building inspector can identify a *potential* heaving bedrock problem in a home if it has manifested itself visually and then advise an investigation by an engineer. Formal identification of the problem must be made by a professional (licensed) engineer, who can perform analysis and make recommendations for repair. For a determination of the potential for development of future problems at a new building site, a professional geotechnical (soils) engineer should be contacted. Refer to the yellow page directory of the phone book for a list of area geotechnical (soils) engineers.

For additional general information on the steeply dipping bedrock issue, contact the following governmental sources:

Colorado Geological Survey
Department of Natural Resources
1313 Sherman St, Room 715
Denver, CO 80203
303-866-2611

Jefferson County
Planning and Zoning Department
100 Jefferson County Pkwy
Golden, CO 80419
303-271-8700

**RELATED TERMS:**

**Backfill.** The earth or gravel used to fill in the excavation pit created during near or around the foundation perimeter.

**Caisson.** See Pier.

**Crawlspace.** A shallow space between the floor of a house and the ground.

**Differential Movement.** Uneven settlement or heaving of the structure. It may cause cracks in walls and ceilings, sloping floors, windows and doors that bind. When severe, it may lead to catastrophic structural failure.

**Downspout.** A vertical pipe made of concrete, metal, clay or plastic that carries storm water from the roof gutter to the ground. It is part of the roof drainage system.

**Downspout extension.** A horizontal pipe made of concrete, metal, clay or plastic that is attached to the base of the downspout. It carries storm water away from the building foundation area.

**Drain tile.** A pipe placed next to the foundation bottom that helps drain water away from the building foundation.

**Drilled Pier.** A column, usually of steel reinforced concrete, that is evenly spaced under a structure to support its weight. Foundation piers are formed by drilling holes in the earth to a prescribed depth and pouring concrete into them. Foundation piers that support some structure, such as bridges, may be above the ground. Sometimes called caissons or drilled piers.

**Footing.** A base under a foundation that is wider than the structure and distributes the weight of the structure to the earth.

**Foundation.** The element of a building that supports the superstructure.

**Foundation wall.** A concrete or masonry wall below grade that serves as part of the foundation. Foundation walls make up the walls of the basement or crawlspace.

**Heaving.** Upward movement or lifting caused by frost or soil swell.

**Pier.** See Drilled Pier

**Roof Drainage System.** A storm system composed of gutters, downspouts, extensions, and splashblocks which carry rainwater and snow melt away from the structure.

**Settlement.** Downward movement or shifting that is caused by soil movement, compaction, or shrinking.

**Slope.** The ratio of the rise over the run. Typically relates to the water sheading capability of a roof or ground surface.

**Subsurface Drainage.** A below-ground drainage system designed to lower the water table below the basement slab and/or divert water away from the structure. See also french drain, interceptor drain, and peripheral drain.

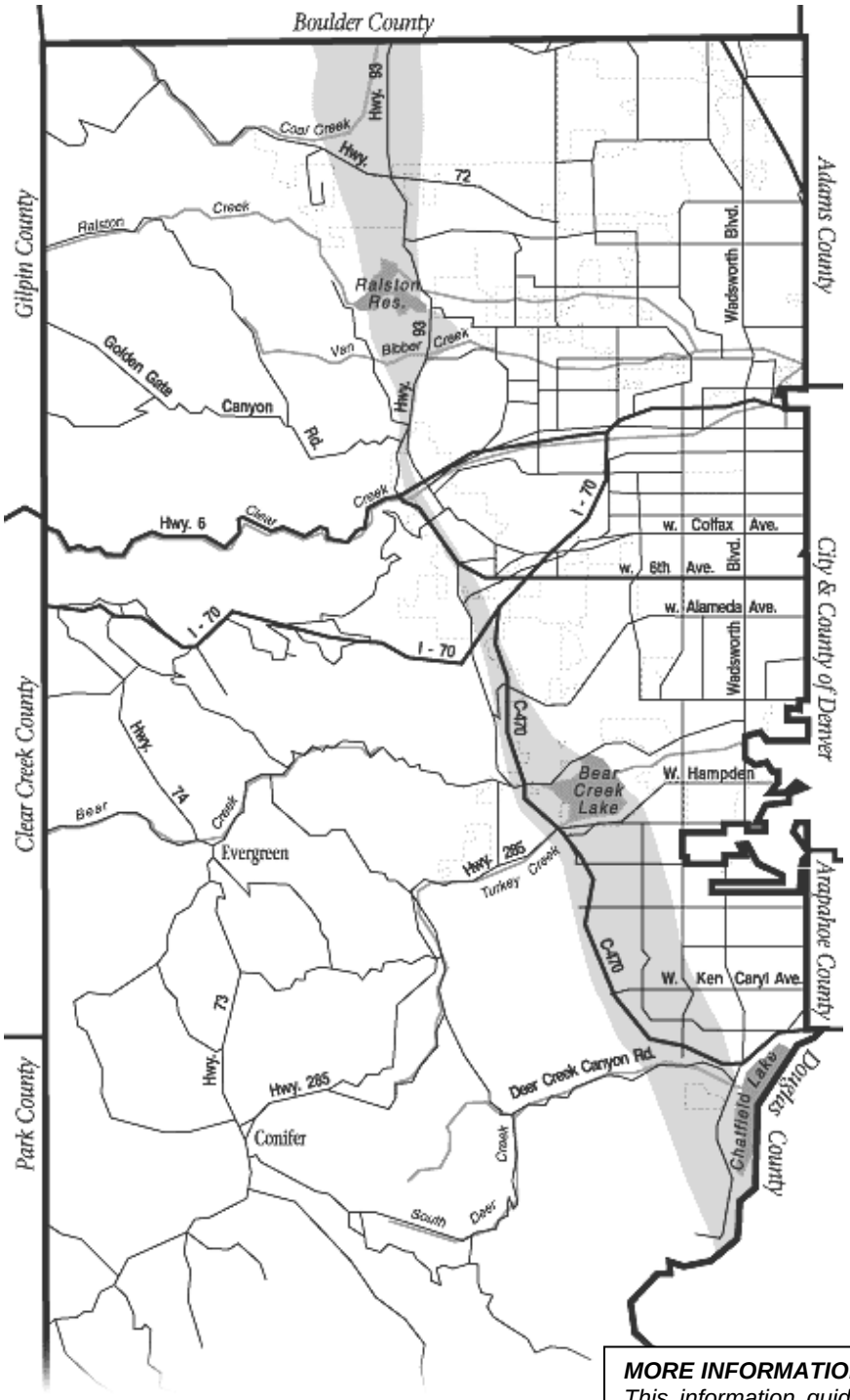
**Sump.** A pit or reservoir located in the basement or crawlspace that is used for collecting water that is subsequently discharged from the sump by a sump pump.

**Sump pump.** An automated electric pump that discharges water that has collected in the sump.

**Superstructure.** That part of the building structure that is above the top of the foundation walls.

**Swell potential.** The maximum amount of expansion that can develop when a particular sample of soil containing clay minerals swells upon wetting.

**Jefferson County, Colorado**
**Designated Dipping Bedrock Area**




***MORE INFORMATION***

*This information guide was written by Joseph "Joe" Wujek, a Professor of Architectural Engineering Technology at Front Range Community College, Westminster, Colorado, a Visiting Lecturer in Architectural Engineering at the University of Colorado, and owner/inspector of Advanced Building Consultants, LLC, a Colorado home/building inspection firm. Due to the general scope of the material presented herein, this document should not serve as a complete commentary on this issue. Feel free to contact Joe for more information.*