National Flood Insurance Program
Community Rating System

Special Hazards Supplement to the *CRS Coordinator's Manual*

2006

FEMA

A community interested in more information on obtaining flood insurance premium credits through the Community Rating System (CRS) should have the *CRS Application*. This and other publications on the CRS are available at no cost from

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Introduction

The Community Rating System (CRS) rewards communities that are doing more than meeting the minimum requirements of the National Flood Insurance Program (NFIP) to help their citizens prevent or reduce flood losses. The CRS also provides an incentive for communities to initiate new flood protection activities. The goal of the CRS is to encourage, by the use of flood insurance premium adjustments, community and state activities beyond those required by the NFIP to:

- Reduce flood losses, i.e.,
  - protect public health and safety,
  - reduce damage to buildings and contents,
  - prevent increases in flood damage from new construction,
  - reduce the risk of erosion damage, and
  - protect natural and beneficial floodplain functions;
- Facilitate accurate insurance rating; and
- Promote the awareness of flood insurance.

The CRS includes 18 creditable activities, organized under four categories or series:

300—Public Information

400—Mapping and Regulations

500—Flood Damage Reduction

600—Flood Preparedness.

Credit points are based on the extent to which an activity advances the three goals of the CRS. Communities are invited to propose alternative approaches to these activities in their applications.

The Federal Emergency Management Agency (FEMA) and many communities in the United States have long recognized that the mapping and minimum regulatory standards of the NFIP do not adequately address all of the flood problems in the country. In particular, a number of “special” flood hazards deserve attention. They include

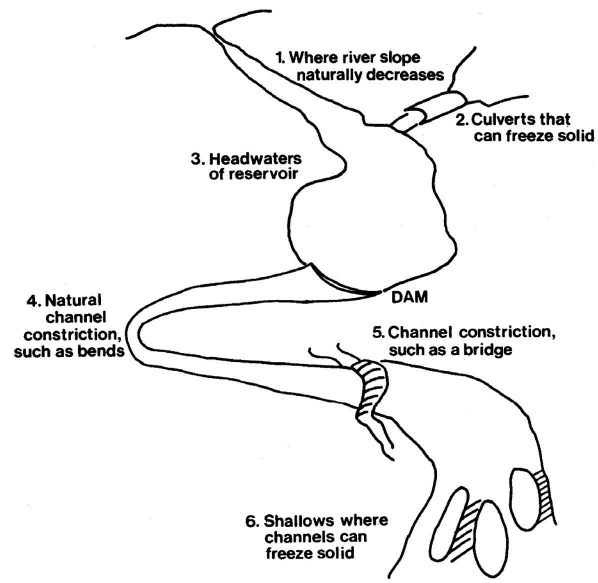
- Ice jam flooding,
- Flooding adjacent to closed basin lakes,
- Mudflow hazards,
- Flooding affected by land subsidence,
- Uncertain flow path flood hazards,
- Coastal erosion, and
- Tsunamis.

This publication discusses the credits provided by the CRS for mapping and management of the first five of these hazards. Coastal flood hazards are addressed in the publication *CRS Credit for Management of Coastal Erosion Hazards*, and tsunami hazards are addressed in the publication *CRS Credit for Management of Tsunami Hazards*. Both are supplements to the *CRS Coordinator's Manual*, and include additional Schedule sections and Commentary.

BACKGROUND ON THE SPECIAL HAZARDS

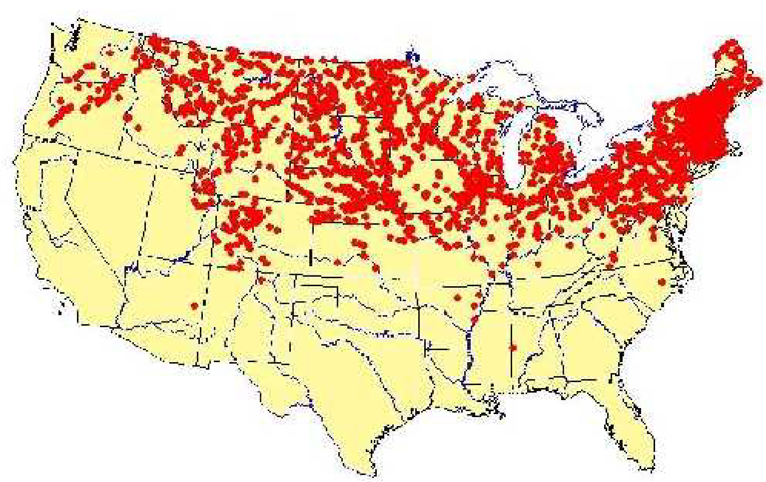
Ice Jam Flooding

An ice jam may be defined as an accumulation of ice in a river, stream, or other flooding source that reduces the cross-sectional area available to carry the flow and increases the water-surface elevation. Ice usually accumulates at a natural or human-made obstruction or a relatively sudden change in channel slope, alignment, or cross-section shape or depth. Ice jams are common in locations where the channel slope changes from relatively steep to mild, and where a tributary stream enters a large river. Ice jams often cause considerable increases in upstream water surface elevation, and the flooding often occurs quite rapidly after the jam forms (FEMA, 2002).



Typical ice jam locations (from Association of State Floodplain Managers).

In many northern regions, ice covers the rivers and lakes annually. The yearly freezeup and breakup usually take place without major flooding. However, some communities face serious ice jam threats every year, while others experience ice-jam-induced flooding at random intervals. The former often have developed emergency plans to deal with ice jam problems, but the latter are often ill-prepared to cope with a jam.



Distribution of ice jam events in the continental United States as of September 1999 (from U.S. Army Corps of Engineers, 2006a).

In a 1992 survey, the U.S. Army Corps of Engineers District and Division offices reported ice jam problems in 36 states, primarily in the northern tier of the United State. However, even mountainous regions as far south as New Mexico and Arizona experience river ice. Ice jams affect the major navigable inland waterways of the United States, including the Great Lakes. A study conducted in Maine, New Hampshire, and Vermont identified over 200 small towns and cities that reported ice jam flooding over a 10-year period. In March 1992 alone, 62 towns in New Hampshire and Vermont reported ice jam flooding problems after two rainfall episodes.


Ice jam flood on the Iroquois River, Illinois, March 1979 (photo from Kankakee County Planning Department).

Ice jams in the United States cause approximately $125 million in damage annually, including an estimated $50 million in personal property damage and $25 million in operation and maintenance costs to navigation, flood control, and channel stabilization structures.

Because ice jam floods are less common and more poorly documented than open-water floods, it is more difficult to characterize these events compared to open-water flooding. In addition, because of the complex processes involved in the formation and progression of ice jams and the highly site-specific nature of these jams, these events are more difficult to predict than open-water flooding. The rates of water level rise can vary from feet per minute to feet per hour during ice jam flooding.

There are generally two types of ice jams:

- Frazil ice freezes the river and forms a dam.
- When warm weather and rain break up frozen rivers or any time there is a rapid cycle of freezing and thawing, broken ice floats downriver until it is blocked by an obstruction such as a bridge or shallow area.

In both cases, an ice dam forms, blocking the channel and causing flooding upstream. Ice jams present three hazards:

- Sudden flooding of areas upstream from the jam, often on clear days with little or no warning,
- Sudden flooding of areas downstream when an ice jam breaks. The impact is similar to a dam break, and damages or destroys buildings and structures.
- Movement of ice chunks that can push over trees and crush buildings (see photo, next page).

Ice jams tend to recur at the same locations on streams, and ice jam flood elevations have a recurrence interval just like clear water floods. Because freezeup jams rely heavily on periods of intense cold that produce large quantities of frazil ice, they can be somewhat easier to predict than breakup jams, which are caused by a site-specific combination of complex physical processes. Evaluation of historical ice, meteorological, and hydrological records is necessary for developing a prediction method for either type of jam.

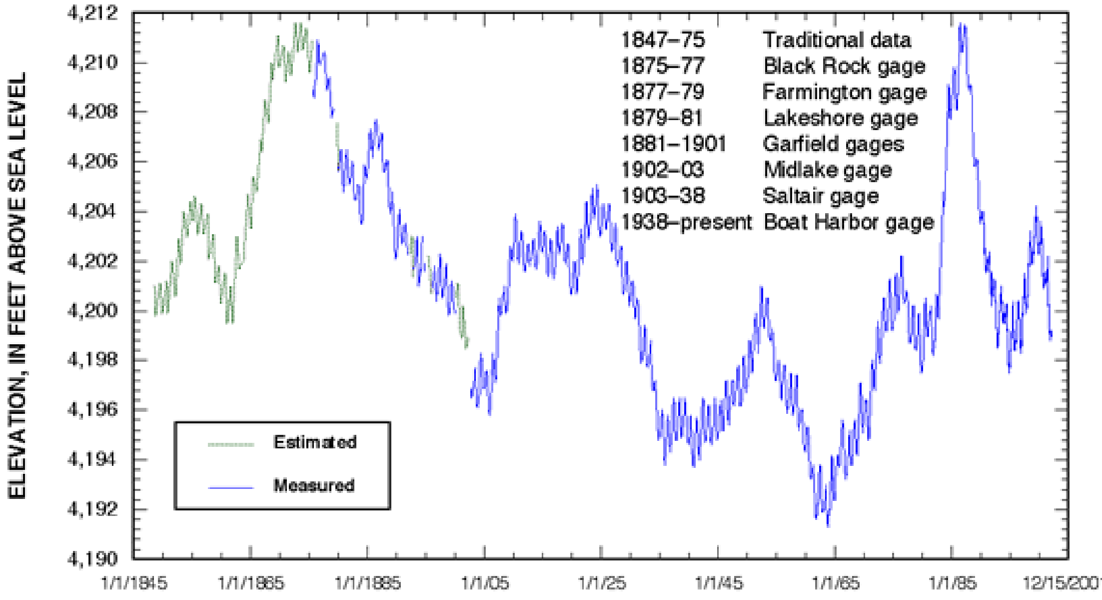
Kankakee River ice jam damage, 1982
(photo from French & Associates, Ltd.).

Hazards Related to Closed Basin Lakes

Two types of lakes pose special hazards to adjacent development: lakes with no outlets, like the Great Salt Lake and the Salton Sea; and lakes with inadequate, regulated, or elevated outlets, such as the Great Lakes and many glacial lakes. All of these are referred to as "closed basin lakes." Closed basin lakes are subject to very large fluctuations in elevation that can persist for weeks, months, or years.

Closed basin lakes occur in almost every part of the United States for a variety of reasons. Lakes in the northern tier of states and Alaska were scoured out by glaciers. Lakes with no outlets (playas) formed in the West as a result of tectonic action. Oxbow lakes along the Mississippi and other large rivers are a consequence of channel migration. Sinkhole lakes formed where there are large limestone deposits at or near the surface and adequate surface water and rainfall to dissolve the limestone (karst topography).

The Great Salt Lake in Utah is perhaps the best known closed basin lake in the United States. There is little permanent development adjacent to the Great Salt Lake, but there is a thriving tourism industry, and roads and railroads near the lake are affected by high lake levels. The graph on the next page shows how the persistence of high (or low) lake



Level of the Great Salt Lake, Utah, 1847–2001. The Great Salt Lake is located on a shallow playa, so small changes in the water surface elevation result in large changes in the surface area of the lake. This is particularly evident when the lake spills into the west desert at an elevation of about 4215 feet, greatly increasing its area. … At the historic average (1847-1986) surface elevation of 4,200 feet …, the lake covers an area of about 1,700 square miles. At the historic low elevation of 4,191.35 in 1963, the lake covered only 950 square miles. The drop of about 8.5 feet in elevation resulted in a loss of about 44 percent in surface area. During 1986 and again in 1987, the lake reached an elevation of 4,211.6 feet and had a surface area of about 3,300 square miles (USGS, 2006).

levels mean everything to management of development adjacent to closed basin lakes. Imagine that a flood protection level for the great Salt Lake were set at 4,212 feet msl. No buildings would have flooded during the 185 years of lake level records.

Hazards Related to Mudflows

Mudflows (or debris flows) are rivers of rock, earth, and other debris saturated with water. They occur when water rapidly accumulates in the ground, such as during heavy rainfall or rapid snowmelt, changing the earth into a flowing river of mud or “slurry.” A slurry can flow rapidly down slopes or through channels, and can strike with little or no warning at avalanche speeds. A slurry can travel several miles from its source, growing in size as it picks up trees, cars, and other materials along the way.

Although floods and mudflows are covered under the NFIP, landslides are not covered. Typically, a combination of flooding, mudflow and landslide conditions can occur in the same general area. Under a flood insurance policy a property is covered for the portion of the damage to the insured building or contents caused by the flooding and mudflow, but not the portion of the damage caused by the landslide.

Mudflows are common types of fast-moving landslides. These flows generally occur during periods of intense rainfall or rapid snow melt. They usually start on steep hillsides as shallow landslides that liquefy and accelerate to speeds that are typically about 10 miles per hour, but can exceed 35 miles per hour. The consistency of debris flows ranges from watery mud to thick, rocky mud that can carry large items such as boulders, trees, and cars.


March 1999 ice jam on the First Branch White River, Tunbridge, Vermont (photo from U.S. Army Corps of Engineers 2006b).

Mudflows from different sources can combine in channels, and their destructive power may be greatly increased. They continue flowing down hills and through channels, growing in volume with the addition of water, sand, mud, boulders, trees, and other materials. When the flows reach flatter ground, the debris spreads over a broad area, sometimes accumulating in thick deposits that can wreak havoc on developed areas.

Hazards Related to Land Subsidence

The U.S. Geological Survey (USGS) and others have been studying the phenomenon of land subsidence, its causes, and its impacts for at least 100 years. USGS Circular 1182 provides background information on land subsidence and case studies, quoted below.

> Land subsidence is a gradual settling or sudden sinking of the Earth's surface owing to subsurface movement of earth materials. Subsidence is a global problem and, in the United States, more than 17,000 square miles in 45 States, an area roughly the size of New Hampshire and Vermont combined, have been directly affected by subsidence. . . . More than 80 percent of the identified subsidence in the Nation is a consequence of our exploitation of underground water, and the increasing development of land and water resources threatens to exacerbate existing land subsidence problems and initiate new ones. In many areas of the arid Southwest, and in more humid areas underlain by soluble rocks such as limestone, gypsum, or salt, land subsidence is an often-overlooked environmental consequence of our land- and water-use practices (Galloway et al., 1999, p. 1).
>
> In 1991, the National Research Council estimated that annual costs in the United States from flooding and structural damage caused by land subsidence exceeded $125 million. The assessment of other costs related to land subsidence, especially those due to groundwater withdrawal, is complicated by difficulties in identifying and mapping the affected areas, establishing cause-and-effect relations,

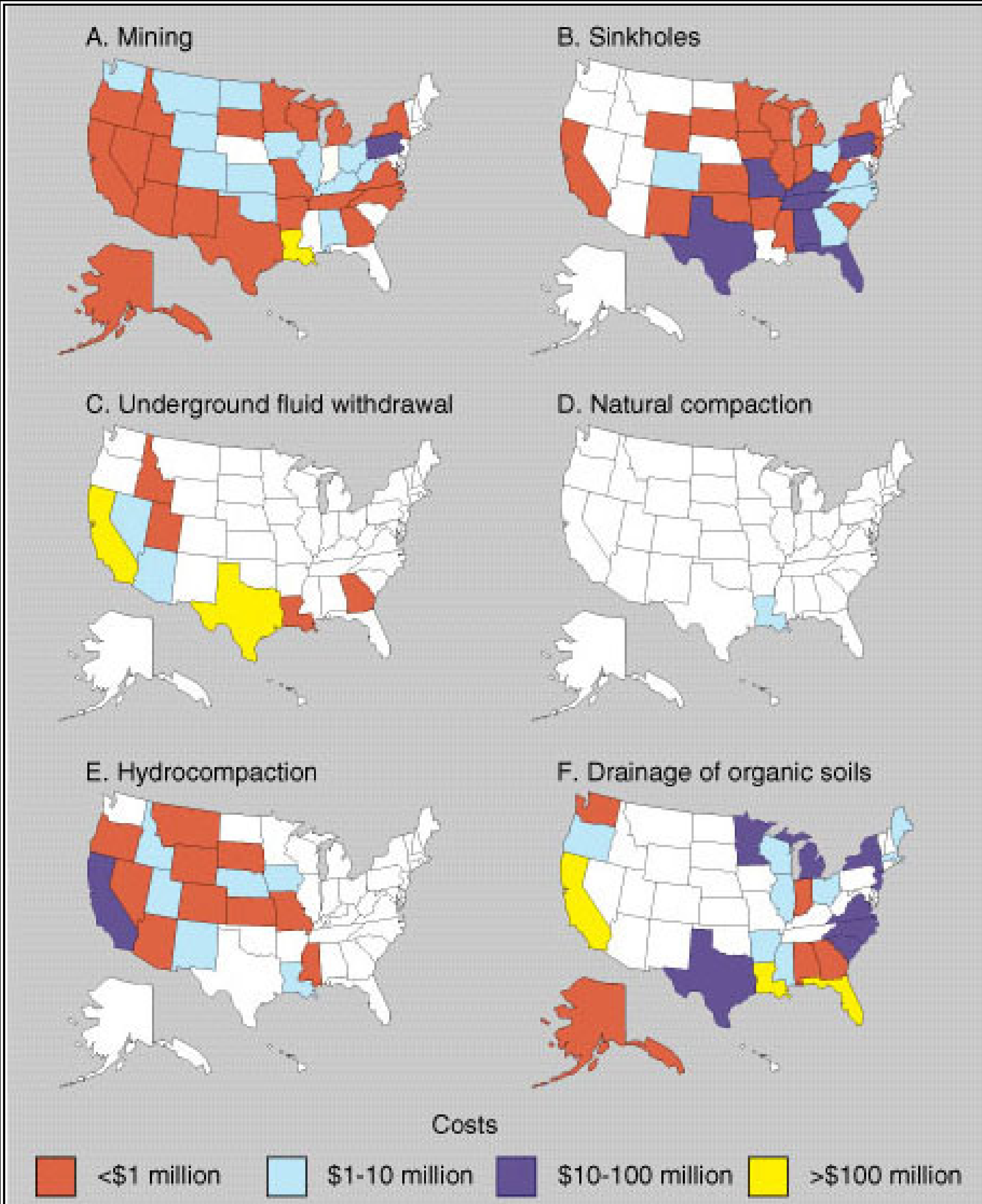


Figure 1. Distribution of subsidence problems in the United States estimated by the National Academy of Sciences (1991). Damage costs are conservative estimates for an unspecified period and are intended to show only relative magnitudes for state-by-state comparisons. The estimates do not reflect annual costs to control or mitigate damage from subsidence.

Subsidence problems in the United States (from Leake, 1997).

assigning economic value to environmental resources, and by inherent conflicts in the legal system regarding the recovery of damages caused by resource removal under established land and water rights. Due to these “hidden” costs, the total cost of subsidence is probably significantly larger than our current best estimate (Galloway et al., 1999, p. 1).

Evidence of a subsidence fault on Highway 11 bridge. (photo from Lake Pontchartrain Basin Foundation).

Several other types of subsidence involve processes more or less similar to the three mechanisms just cited, but are not covered in detail in this Circular. These include the consolidation of sedimentary deposits on geologic time scales; subsidence associated with tectonism; the compaction of sediments due to the removal of oil and gas reserves; subsidence of thawing permafrost; and the collapse of underground mines. Underground mining for coal accounts for most of the mining-related subsidence in the United States and has been thoroughly addressed through Federal and State programs prompted by the 1977 Surface Mining Control and Reclamation Act. No such nationally integrated approach has been implemented to deal with the remaining 80 percent of land subsidence associated with ground-water processes (Galloway et al., 1999, p. 3).

An earlier study noted that “Ideally, the development of sinkholes can be eliminated or minimized by ceasing the pumpage that causes the decline of the water table. The cessation of or drastic decrease in sinkhole activity following a recovery of the water table has been recognized previously. Most efforts . . . have been directed toward measures minimizing sinkhole development and eliminating potential hazards and damage to structures rather than dealing with the cause” (Newton, 1984, p. 250).


A recent sinkhole in Huntsville, Alabama (photo from Dr. Warren Campbell).

Subsidence increases the Frequency and Intensity of Flooding

Located along a low-lying coast that is subject to tropical storms, the Houston area is naturally vulnerable to flooding. In coastal areas, subsidence has increased the amount of land subject to the threat of tidal inundation. Flooding by tidal surges and heavy rains accompanying hurricanes may block evacuation routes many hours before the storms move inland, endangering inhabitants of islands and other coastal communities. The increased incidence of flooding in coastal areas eventually led to the growing public awareness of subsidence and its costs.

The fate of the Brownwood subdivision of Baytown affords a particularly dramatic example of the dangers of coastal subsidence. Brownwood was constructed, beginning in 1938, as an upper-income subdivision on wooded lots along Galveston Bay (Holzschuh, 1991). At that time the area was generally 10 feet or less above sea level. By 1978 more than 8 feet of subsidence had occurred.

> *The subdivision is on a small peninsula bordered by three bays. [It] is a community of about 500 single-unit family houses. Because of subsidence, a perimeter road was elevated in 1974 to allow ingress and egress during periods of normal high tide [about 16 inches], and to provide some protection during unusual high tide. Pumps were installed to remove excess rainfall from inside the leveed area. Because of subsidence after the roadway was elevated, tides of about [4 feet] will cause flow over the road. The United States Army Corps of Engineers studied methods to protect the subdivision from flooding. The cost of a levee system was estimated to be about $70 million. In 1974, the Army Corps estimated that it would cost about $16 million to purchase 442 homes, relocate 1,550 people, and convert [750 acres] of the peninsula into a park.*
>
> *This proposed solution was approved by the Congress of the United States and provided necessary funding. However, the project required that a local sponsor (the City of Baytown) should approve the project, provide 20 per cent of the funds ($3 million) and agree to maintain the park. By the time the first election to fund the project was held on 23 July 1979, the cost estimate had increased to $37.6 million, of which the local share was $7.6 million. The proposal was defeated, and two days later 12 inches of rain fell on Brownwood causing the flooding of 187 homes. Another bond election was held on 9 January 1980 and again the proposal was defeated. Accepting the residents' decision, Baytown officials began planning the sale of $3.5 million worth of bonds to finance the first stage of a fifteen-year, $6.5-million programme to upgrade utilities in the subdivision. Meanwhile, those who own the houses generally also owe mortgages and cannot afford to purchase other homes. Although they continue to live in the subdivision many have to evacuate their homes about three times each year (Gabrysch, 1983, p. 42).*

The year that article was published, Hurricane Alicia struck a final blow to Brownwood. All homes in the subdivision were abandoned. Today, most of the subdivision is a swampy area well-suited for waterfowl; egrets and scarlet ibis are often seen (Galloway et al., 1999, p. 42).

Hazards Related to Uncertain Flow Path Flooding

Uncertain flow path flooding includes alluvial fan flooding and hazards associated with moveable bed streams. These hazards differ from other flood hazards in that they usually include the added hazard of large quantities of moving debris and sediment, and the location and nature of the flood hazard changes over time.

One of the uncertainties about moveable bed streams is the change in the stability of the channel over time. Throughout much of the arid and semi-arid regions of the United States, there is evidence that human activities over as short a time as a decade have drastically changed the nature of some streams. It is important to understand the causes of aggradation, degradation, and channel migration in order to project the future configuration of the channel.

Alluvial Fan Hazards

As defined in 44 *CFR* 59.1, "alluvial fan flooding" means flooding that occurs on the surface of an alluvial fan or similar landform, originates at the apex, and is characterized by high-velocity flows; active processes of erosion, sediment transport, and deposition; and unpredictable flowpaths.

FEMA's *Guidelines for Determining Flood Hazards on Alluvial Fans* (FEMA, 2000) generally addresses many of the issues raised in *Alluvial Fan Flooding* (National Research Council, 1996). "This document provides guidance for the identification and mapping of flood hazards occurring on alluvial fans, irrespective of the level of fan forming activity. The term alluvial fan flooding encompasses what will be described as active alluvial fan flooding and inactive alluvial fan flooding" (FEMA, 2000, p. 1).

> Alluvial fans do not exhibit the more predictable behavior and well-defined boundaries normally found in most riverine floods. The behavior and path of floodwater in any individual event as it proceeds from the apex to the toe is a direct result of the flood processes previously illustrated. These processes vary as a function of the flow's sediment content and velocity, the fan's slope, soil and vegetative cover, and types and amount of fan development.
>
> Alluvial fan flows are subject to lateral migration and sudden relocation during the course of a flood, and may not even follow the same path in subsequent floods; in any flood event, however, a part of the fan will always be subject to flood hazards. Thus, it is generally not appropriate to utilize the location of past flow-paths in the prediction of future floods. The full range of hazards that occur on fan include:
>
> - High velocity flow (as high as 15 – 30 feet per second), producing significant hydrodynamic forces (pressure against buildings caused by the movement of flowing water)
> - Erosion/scour (to depths of several feet)

Alluvial fan extending from the Panamint Mountains in the background to the floor of Death Valley in the foreground (Miller, 1995, p. 18).

- Deposition of sediment and debris (depths of 15–20 feet have been observed)
- Debris flows/impact forces
- Mudflows
- Inundation, producing hydrostatic/buoyant forces (pressure against buildings caused by standing water)
- Flash flooding (little, if any, warning time) (FEMA, 1989).

Streams with Aggrading, Degrading, and Migrating Channels

For the purposes of this discussion, areas subject to uncertain flow paths will include streams where erosion (degradation of the streambed), sedimentation (aggradation of the streambed), channel migration, or combinations of these processes cause sufficient changes in the topography of the stream and/or its floodplain to affect the flood elevation or the delineation of the floodplain or floodway. In some locations, these processes may occur simultaneously, or one process may occur in one event while another process occurs in a subsequent event.

All of the floodplains in the world are formed by the eroding of mountain and the deposition of the eroded material on the floodplains. There is an equilibrium among the rainfall, the sediment source, the slope of the watershed, and the slope of the floodplain. The equilibrium is different for each stream, but there are regional similarities and differences. These differences may require different approaches to mapping and management of their floodplains.

Sedimentation and erosion make traditional methods of mapping and management of flood hazards more difficult. Some stream reaches aggrade, some degrade, and in some reaches, the channels change their course within the floodplain, even from one flood to the next.

CRS CREDIT

The hazards associated with ice jam flooding, flooding adjacent to closed basin lakes, mudflow hazards, flooding affected by land subsidence, and uncertain flow path flooding must be dealt with at the community level using all of the tools used in conventional floodplain management. Under the CRS, these tools are organized under four series of credited activities:

- Informing the public and specific populations, such as developers and engineers, about the hazards (300 series)
- Mapping and regulation of the hazard areas with recognition of the unique problems associated with the hazards (400 series)
- Special structural and nonstructural efforts to solve existing problems (500 series) and
- Special emergency preparedness efforts that recognize the particular problems associated with these hazards (600 series).

This section reviews the proven mitigation measures for the five special hazards addressed in this publication. In some cases, CRS credit is provided for an activity in the *CRS Coordinator's Manual*. In other cases, particularly in the 400 series, special credit is provided in this publication. For those credits, this document is a supplement to the Schedule and Commentary in the *Coordinator's Manual* and the same formatting is used. The special hazard credit points calculated under this publication are transferred to the regular credit points in the *Coordinator's Manual*.

Just as riverine and coastal flood hazards require different mapping and management techniques, these special hazards require different techniques as well. This does not require a different or separate department in local government, just an additional set of standards that recognize the features of these flood hazards and the appropriate use of the public information, engineering, planning, and other staff.

A number of CRS activities have credit for the special hazards discussed in this publication. However, a community's special hazard management program should include other activities that do not receive CRS credit. For example, post-disaster recovery and mitigation policies might require damaged areas to be redeveloped with new street patterns to accommodate the clustering of structures away from high hazard areas.

On the next few pages are some fictitious examples of communities with areas subject to these special hazards. Note that in each case, special techniques are used to map the hazards, and special regulatory requirements have been adopted to mitigate them.

The first fictitious example shows why and how a local government might develop a program to deal with ice jam hazards and how the CRS would recognize its efforts.

Example 100IJ. North County is generally hilly, with the North River running generally south to north through the center of the county. North City, the main population center in the county, lies on both sides of the North River near the center of the county.

The North River has a history of ice jams both near the northern edge of the county, where there is virtually no development, and within North City. Ice jams in North City have caused flood damage in the adjacent county.

The 1987 Flood Insurance Study for North County and North City used river gage data for the North River to determine the base flood peak flow and the base flood elevation (BFE). Since 1987, three ice jam floods have caused higher flood elevations than the BFE in North City, and two caused higher flood elevations in the county. After the 1993 floods in the upper Midwest, North County requested a restudy of the North River. FEMA agreed to do a county-wide restudy.

The restudy developed new hydrology for the North River based on river gage data that included the 1993 flood. The study contractor was also instructed to do a separate analysis for flood elevations under ice jam conditions. The resulting base flood based on river gage data has a peak flow about 15% larger than that in the 1987 study, and the resulting BFE was the same as the 50-year elevation from ice jam flooding in and upstream from North City. An ice jam analysis was also done for the undeveloped area near the northern edge of the county. Again, the new BFE based on clear water flooding was the same as the elevation of the 50-year ice jam flood.

For the reaches of North River that have experienced ice jam flooding, North County established a regulatory requirement that every new building in the Special Flood Hazard Area (SFHA) must have an engineering analysis of its foundation to ensure that it is safe from moving ice at the ice jam flood elevation, which is three feet higher than the BFE. They also prohibited development in the floodway of the North River in those reaches. The county also established zoning with a minimum lot size of 3 acres for the area near the northern edge of the county.

North County had joined the CRS after the 1993 flood as a Class 9 community. In 1996, when its revised FIRM was adopted along with its higher regulatory standards for areas subject to ice jam hazards, it improved to Class 8. The county received considerable credit for preservation of open space (Activity 420) because of its prohibition on development in floodways where there is an ice jam hazard. In Activity 430, the county received CRS credit for its foundation requirements in areas subject to ice jam hazards, and for low density zoning.

Lake City is a fictitious county in the upper Midwest. The following example shows why and how a community might develop a program to deal with closed basin lake hazards.

Example 100CB. Lake City is a growing city of about 60,000 people located on the east end of Glacial Lake. Glacial lake is about 10 miles long from east to west and about 3 miles across at its widest point. There are small resorts and residences around the lake. Almost all of the land around the lake is owned by a paper company, and these resorts and residences are on land leased from the company.

Glacial Lake is a closed basin lake. Sporadic records have been kept of lake levels for a long time. A trading post built in 1810 atop a rock outcrop was flooded and abandoned in 1825. Farms were established in the area in the 1840s, and several farmers kept records of high and low lake levels until the farms failed because of a drought in the late 1870s. At that time, a lumber company began acquiring the homesteads at tax sales. In 1898, Lake City was established as a mill town. Since World War II, the area has attracted summer vacationers, and the lumber mill has been replaced by a paper mill. The paper mill and tourism are now of about equal importance to Lake City, and tourism and retirement appear to be the economic future of the area.

The water level in Glacial Lake began rising in 1985, and by 1990, buildings all around the lake had been flooded. Lake City asked the U.S. Army Corps of Engineers to study the problem and develop a project to deal with it. The Corps determined that

- Lake levels have varied from about 976 feet to 1,010 feet above mean sea level (msl) since 1810.
- The natural outlet from the lake is at 1,015 feet msl
- The buildings flooded in 1990 were built between 1,000 feet and 1,005 feet msl.
- Lake levels never reached 1,000 feet msl between the drought in the 1870s and 1989.
- The City's FIRM was based on a lake level of 1,001 feet msl.
- The lake has probably not had an elevation above 1,005 feet msl since 1825, when the trading post was flooded.
- Winds from the west during the spring, when lake levels are highest, raise the lake level at Lake City about 6 inches (windset), and cause 18-inch waves.
- No structural project would provide protection from the highest potential lake elevations.

Lake City and the paper company discussed this situation and decided to work together to solve the flood problem. In 1990, Lake City had two miles of lakefront. There were 510 buildings in the City at an elevation less below 1,012' feet msl. The area of the City that was below 1,012 feet msl was about 200 feet wide and included 50.8 acres. The paper mill, the downtown area, and the mall on the highway were all above 1,012 feet msl.

The paper company had a 160-acre lakefront parcel that had been used as a dump by the lumber mill and the paper mill from 1898 until 1975. This parcel abutted the City on its south side. Although the site was not especially hazardous, it was a U.S. Environmental Protection Agency superfund site because runoff from the site degraded the water quality of the lake. The company ceded this land to the City.

In 1992, the City adopted a master plan to relocate all buildings below 1,010 feet mean sea level to the superfund site, which was named Glacial Lake Park. Ninety-eight acres of Glacial Lake Park is above 1,012 feet msl. The City prohibited new buildings on land lower than 1,010 feet and required new buildings on land between 1,010 feet and 1,012 feet to be placed on fill with floodproofed utilities. They stated that 1,010 feet msl was the BFE for Glacial Lake, and that they added 2 feet of freeboard to account for windset and wave action.

From 1992 through 1994, the City secured funds from EPA, the Corps, and FEMA to clean up the site. The citizens voted bonds to install streets and utilities as the area developed. The City offered free lots to lakefront residents who would relocate from their floodprone houses to Glacial Lake Park and deed their property to the City. By 1995, 102 buildings had either been moved to the Park or demolished. When the lake rose to 1,007 feet msl in 1999, 396 buildings were moved or demolished. The remaining 12 buildings were on land above 1,010 feet. Six of these buildings were already above 1,012 feet and the others were raised to that elevation. The 1999 relocations were facilitated by NFIP funds, including payments under Increased Cost of Construction coverage, a grant from the Corps, and funds from the state.

By 2000, the City had converted 48 acres of the abandoned area to a City park.

Lake City had been too busy solving its flood problems to join the CRS until 2000. When it joined the CRS in 2000, it was rated a Class 6 community.

Steep County is a fictitious county in the West. The following example is intended to show why and how a community might develop a program to deal with mudflow hazards.

Example 100MF. The western half of Steep County is a broad, relatively level river valley. The eastern half is foothills and mountains. Historically, more than 90% of Steep County's population lived in the valley, but in recent decades, more people are moving into the canyons in the foothills, and the year-round recreational amenities in the higher mountains have led to the development of large resorts and condominium complexes almost all the way to the tops of the mountains.

In the valley, floodplain management had been dealing with the problems associated with uncertain flow path flood hazards. During the 1990s, sediment transport modeling was used to delineate the floodplains for streams flowing from the mountains to the large river to the west.

In 1998, a different hazard became important to Steep County. Unusually heavy snows during the late winter, combined with a warm rainstorm in the early spring caused near-record flooding in the valley, but it also caused numerous landslides and mudflows in the foothills and mountains. The mudflows destroyed a considerable amount of new development and killed 12 people.

Steep County immediately contacted the State Department of Mining and Geology (DMG). DMG did a reconnaissance study that showed that there were numerous areas in both the foothills and farther up in the mountains that showed historic signs of landslide activity, and that recent development and road building had increased the probability of future landslides.

Steep County contracted with DMG to map the geologic hazards in western Steep County. The maps were completed in 2000. After three months of public hearings, Steep County adopted the DMG maps and a geologic hazards regulation. In some areas, the regulation prohibits development, and in other areas, it requires engineering and geologic studies before development, road building, or clearing or disturbing the surface.

In 2001, Steep County updated its comprehensive plan. The CRS planning process was used to receive CRS credit in Activity 510, and the geologic hazards maps and regulations were included in the plan.

Throughout the process of developing the geologic hazards maps and regulations and the development of the comprehensive plan, Steep County had mounted a public information campaign on landslide and mudflow hazards in the foothills and in the mountains.

As a result of the comprehensive plan, the County adopted regulations requiring two feet of freeboard above the BFE for all watercourses with slopes greater than 5%. This provision allows for the sudden accumulation of sediment in channels downstream from landslides and mudflows. When a landslide occurs, it typically flows down a steep slope into a channel with a much shallower slope. The soil and rocks stop, raising the flood elevation. Subsequent flows erode the material away and carry it downstream. The freeboard was intended to provide protection during this process.

Because of these actions and other efforts of the Steep County staff, the County received CRS credit for Activities 330—Outreach Projects, 340—Hazard Disclosure, 350—Flood Hazard Information, 360—Flood Protection Assistance, 410—Additional Map Data, 420—Open Space Preservation, 420LDC—Land Development Criteria, 430—Higher Regulatory Standards, 440—Flood Data Maintenance, and 510—Floodplain Management Planning.

These activities improved Steep County’s CRS class to 6, meaning that buildings in the floodplains shown on the FIRM receive a 20% discount on their NFIP premiums, and buildings outside the SFHA receive a 10% discount.

Flat County is a fictitious county in the West. Its experience shows why and how a community might develop a program to deal with land subsidence hazards.

Example 100SU. The central portion of Flat County is a broad, relatively level river valley. The north and south portions of the County are arid mountains with rocky terrain and virtually no reliable water supply. Flat County was settled by the descendants of Europeans who moved into the area from the eastern United States in the mid to late 1800s. They ranched and developed limited agriculture with the available surface water from the Flat River. Agriculture increased dramatically with the introduction of the windmill, and by the mid 1900s the entire central portion of the County had been irrigated by groundwater pumped from ever-increasing depths.

By the 1990s, three things were becoming apparent. First, traditional kinds of agriculture were becoming uneconomical because of the energy costs for raising water 600 to 700 feet with pumps. Second, the cost of maintaining infrastructure was increasing due to land subsidence. Farms had to be re-leveled to irrigate properly. Ditches had to be replaced with pipes because they no longer had a slope appropriate to carry water. Roads, gas pipelines, and other infrastructure were also requiring more repairs. Finally, floods on the Flat River in the 1990s flooded areas three or four times as wide as the SFHAs shown on FIRMs produced in the late 1970s.

The state geological survey studied Flat County and determined that there had been up to 20 feet of subsidence near the center of the county, immediately adjacent to the Flat River. The average slope of the Flat River through Flat County is 7 feet per mile, but land subsidence had increased the slope to about 9 feet per mile upstream from the center of the subsidence area and decreased the slope to about 5 feet per mile for a 10-mile reach downstream from the center of subsidence. This change in slope caused the channel to downcut in the steeper reach and caused sedimentation in the flatter reach. In the flatter reach, the combination of the lessened slope and the sedimentation resulted in a much wider floodplain.

In 1996, Flat County had a reconnaissance study done to find alternative solutions to the problems of subsidence and flooding. This study concluded that there was no feasible way to reverse the subsidence. It was estimated that if all groundwater pumping ceased immediately, subsidence would continue for another five years, and the maximum amount of subsidence would be about 25 feet. If groundwater pumping continued at the current rate, water would become uneconomical for agriculture in about 10 years, and the ultimate subsidence would be about 30 feet. There were no alternatives for the flood problem except to map and regulate a wider, and widening, floodplain.

After working with the local agriculture interests for two years, in 1998 Flat County secured state and federal funds to acquire the water rights for about 90% of the farm land. The landowners would be allowed to use the land for urban development, which requires only about 7% of the water used for irrigated agriculture.

In 1999, Flat County finalized a long-range comprehensive plan. This plan assumed that the remaining 10% of the farmland would become uneconomical to irrigate by 2010. It also assumed 10% annual population growth through 2010 and 5% annual growth from 2010 through 2020. A hydrogeologic study estimated that subsidence would end in 2030, with a maximum subsidence of about 27 feet. The comprehensive plan included a surface water model that estimated the runoff from development through 2030 as well as the maximum subsidence. Floodplain maps were made based on these conditions. Within the entire area subject to subsidence, the county adopted a special building code provision to require foundations that will resist damage due to subsidence.

Beginning with the results of the reconnaissance study in 1996, Flat County had mounted a public information campaign explaining the nature and the cause of the subsidence problem and the related flood problems. In 1998, it placed a temporary moratorium on development of any land that had been flooded in the big flood of 1995. By 1999, when its comprehensive plan was adopted, it was able to combine local, state, and federal funds to buy conservation easements and offer density trades to preserve about 75% of the floodplain based on 2030 hydrology and subsidence.

Flat County joined the CRS after the 1995 flood. By 2001, it was a Class 8 community. When it adopted the comprehensive plan in 2001, it became a Class 4 community. It receives near maximum credit for all of the public information activities (the 300 series). It received credit for the mapping of the Flat River floodplain and additional credit because it is a special hazard area (Activity 410). It received credit for preservation of open space (Activity 420), and additional credit because it is in a special hazard area. It received credit for 3 feet of freeboard in most of the remaining floodplain because its future-conditions mapping produced flood elevations almost 5 feet higher than existing conditions, the basis for the sale of flood insurance (Activity 430). It also received credit under Activity 430 for foundation protection and land development criteria. Its entire floodplain was entered into a geographic information system (GIS), and it set up a program to obtain new topographic maps every three years using LiDAR. It established a program to resurvey its benchmarks every year (Activity 440).

The comprehensive plan received almost the maximum credit for both stormwater master planning (Activity 450) and floodplain management planning (Activity 510). Because the County had been almost entirely agricultural in 1996, there were only 37 residences in the entire floodplain. By 1999, it had obtained grants from FEMA and the Nature Conservancy to purchase and demolish 20 of these homes (Activity 520).

Arid County is a fictitious county in the arid West. The following example shows why and how a community might develop a program to deal with uncertain flow path flood hazards and how the CRS would recognize that effort.

Example 100UF. The northeast part of Arid County, the Oriental Fan, is subject to alluvial fan flooding where flood water from the desert mountains flows onto the desert floor.

In the western part of the County, two rivers are subject to uncertain flow path flooding.

West River is a perennial stream that carries a heavy sediment load during floods. It flows in a broad sandy-bottomed gorge. The 100-year floodplain just covers the half-mile-wide bottom of the gorge, and the floodway shown on Arid County's Flood Insurance Rate Map (FIRM) averages 300 feet in width.

Dry Creek is a degrading stream for most of its reach in Arid County. Intense development in the upper parts of the Dry Creek watershed since 1950 has caused an estimated 400% increase in the runoff from a 100-year storm. The channel has become incised, increasing the velocity and causing ongoing scour in most reaches within the County

In 1985, the Arid County Flood Control District did a study of the Oriental Fan area. Although the report indicated that the floodplains shown on the County's

FIRM did not accurately reflect the flood hazard in the area, the Board of Supervisors declined to adopt stricter regulations.

In 1987, the Flood Control District completed studies on West River and Dry Creek. They were able to use the County's existing regulations to control development to avoid the worst of the hazards in those areas.

In 1997, a 50- to 100-year storm hit the mountains above the Oriental Fan and the fan itself. More than 100 residences were destroyed by erosion and sediment and debris hitting the structures, 27 more suffered substantial damage, and 300 more were damaged to a lesser degree. Flood depths were less than 3 feet in the affected areas, and the flood was gone 6 hours after it began. Most of the damage occurred outside the SFHA shown on the FIRM. Damage to County and private infrastructure nearly equaled the damage to structures.

Within a week of the Oriental Fan flood, the County Board of Supervisors instructed the Flood Control District to contract for a comprehensive hazard mitigation plan. The District is responsible for the County's floodplain management, stormwater management, and flood warning system, and it is the coordinating agency for the community's participation in the CRS.

The comprehensive plan was produced in a way that would get maximum CRS credit for Activity 510—Floodplain Management Planning. The contractor reviewed the County's Flood Insurance Study, the studies of Oriental Fan, West River, Dry Creek, and numerous other studies conducted by the Flood Control District, the Corps of Engineers, the U.S. Geological Survey, and others. Among other things, they reviewed all flood hazards, alluvial fan hazards, and all moveable bed hazards in the County.

As a result of the hazard mitigation plan, the County adopted development regulations for the Oriental fan area, West River, and Dry Creek, and adopted the maps produced by the Flood Control District in the 1980s. The regulations included a county-wide requirement for retention of stormwater runoff. The Flood Control District also implemented a public information strategy to inform its residents about the County's special hazard areas.

300 Public Information Activities

Because the flood hazards associated with the special hazards are different from "normal" flood hazards, there are special needs for public education. Property owners and developers must be made aware of the hazards and the methods needed to mitigate them.

When a state or local government has mapped special hazard areas, information identifying these areas and how to protect oneself from them should be automatically included in the community's public information program. Likewise, when higher regulatory standards for development in these areas have been adopted, these standards should be included in local public information and education programs.

There are several ways to provide this information, including

- Newsletter and newspaper articles;
- Signs posted in the hazardous areas;
- Brochures and booklets on the hazards and what can be done;
- Outreach projects, such as booths at shopping malls;
- Presentations to civic associations or neighborhood groups;
- Providing information on the location and severity of the hazard areas to inquirers;
- Putting references on the hazard and protection measures in the public library; and
- Providing technical assistance to property owners.

310 Elevation Certificates

Although there is no special or additional CRS credit for elevation certificates in areas of special flood hazard, FEMA elevation certificates, which are required for the purchase of NFIP flood insurance, and which must be maintained by CRS communities, MUST be based upon the current FIRM for the community, and they must be completed using the flood information from the FIRM and the corresponding Flood Insurance Study. There is no requirement to maintain elevation certificates outside the SFHA.

That means that if a community has mapped an area of alluvial fan flooding or an aggrading or migrating channel, and it is regulating areas outside the SFHA, and/or the regulatory flood elevation is higher than that shown on the FIRM, everyone must still use the data from the FIRM for the purpose of filling out the elevation certificate.

320 Map Information

Many communities provide inquirers with flood information from the Flood Insurance Study and FIRM. Some use this opportunity to explain local regulations, including the coastal erosion setback standards. This provides the inquirers with a more complete picture of the local coastal hazard and the importance of regulations as property protection measures.

Providing information from the community's FIRM yields many benefits to residents, businesses, real estate and insurance agents, lenders, and those interested in purchasing, developing, or repairing property. CRS credit is provided for advertising this service and for providing information as described in the *Coordinator's Manual.*

> 6. If the community is receiving CRS credit for mapping and regulating one of the special hazard areas described in Section 401, inquirers must be advised if the property falls within a special hazard area and what precautions should be taken when developing or improving the property.

If the community is receiving CRS credit for mapping and regulating its special hazards, the map information service must include telling inquirers if the property in question is mapped as a special hazard area. The community must also disclose any special hazard regulatory requirements for developing the property. This can help property owners and potential buyers better understand the natural hazards risks of a particular location. Understanding these risks can help property owners and builders identify and evaluate potential property protection measures.

330 Outreach Projects

This activity provides credit for newsletters, mailings, presentations, booths, brochures, and a host of other means of getting the word out to the public or target audiences, such as builders or school children. Credit for some of the elements is based on covering topics such as "flood hazard," "flood hazard map," "flood safety" and "property protection." These topics should include information on the special hazards, in addition to the flood hazard mapped on the Flood Insurance Rate Map.

One of the elements in Activity 330 provides 100 points for developing and implementing a public information program strategy. The community identifies its most important public information needs and identifies the best way to meet those needs. The strategy could focus on special hazards, if the strategy team determines that that is as important or even more important than "normal" flooding. The full credit of 100 points would still be provided.

340 Flood Hazard Disclosure

The CRS provides credit when real estate agents disclose information about a property's flood hazard to prospective buyers. More credit is provided if the disclosure includes other hazards, such as special hazards. State or local mandates for sellers, landlords, or developers to disclose these hazards can receive credit. If real estate agents don't actually disclose a property's hazards, but provide a handout advising house hunters about what to look for and what questions to ask, additional points are provided.

350 Flood Protection Information

Under Activity 350, communities receive credit for putting flood protection information in their public libraries and on their websites. These materials should cover all known flood-related hazards, including special hazards. Additional credit points are specifically provided if the library has references on uncertain flow path hazards, provided they are present in the community. This publication can be cataloged in the library to receive that credit.

The community or the librarian should also review the references at the end of this supplement to identify additional documents that would be helpful locally. Some of the websites mentioned in this publication could also be good links for the community's website coverage of its special hazards and ways people can protect themselves and their property.

> **Example.** Arid County has several publications on alluvial fans in its library, including *Alluvial Fan Flooding*, by the National Research Council. Its website includes several pages on alluvial fan flooding and channel migration, along with an explanation of how the floodplain management ordinance protects new development from damage while enhancing the County's system of linear parks and trails.

360 Flood Protection Assistance

Floodplain residents are more likely to undertake activities to reduce the risks from special hazards to their property if reliable information is available locally. The CRS provides credit if a local government provides technical advice to interested property owners and publicizes that this service is available.

A community that is offering assistance and receiving credit for Activity 360 should have its staff trained about the hazards associated with uncertain flow paths.

> **Example.** Upon requests from property owners, an Arid County staff member will make visits to properties to explain the requirements of its floodplain management ordinance and to help the property owners locate their structures on their property if it is in a delineated alluvial fan, or if it is within a setback area.

400 Mapping and Regulatory Activities

FEMA and many communities have long recognized that the mapping and/or minimum regulatory standards of the NFIP do not adequately address the problems of special hazards. Since these special hazards have the potential for extraordinary flood damage, it is important that communities deal with the hazards in ways that go beyond the minimum NFIP standards.

To protect new development in areas subject to special hazards, a community must have maps that adequately define the hazards and ordinance language that deals with the specific hazards in those areas.

410SH Additional Flood Data for Special Hazard Areas

Mapping criteria for areas with special hazards are discussed in this section. For areas that meet the mapping criteria, credit is provided in Activity 410. All special hazards credits are provided only if those areas are mapped by methods described in this section.

411SH Credit Points

a. Prerequisites for mapping credit:

1. Credit for mapping areas subject to special hazards is only given if the community has special-hazard-related development regulations that receive at least 20 points under Section 420SH and/or Section 430SH.

2. To receive credit for mapping, open space preservation, and/or management of special hazards, either the community or FEMA must either map the hazard areas in detail, or the community must require developers to do so as a condition of any development permit. The mapping technique must be accepted by the FEMA Regional office.

b. Mapping credit for special hazards:

1. Mapping credit for ice jam hazards (MIJ):

   There is no 410SH credit for mapping ice jam hazards because *Flood Insurance Study Guidelines and Specifications for Study Contractors* specifies mapping criteria for this hazard. However, this hazard must be mapped in order for the community to receive credit for management of ice jam hazards in Section 431SH and/or for credit for preservation of open space in these hazard areas under Section 420SH.

   If the community prepares a new map that includes the ice jam technique, it is eligible for regular Activity 410 credit.

Mapping areas subject to ice jam hazards requires a hydrologic analysis of the stream reach that includes ice jam flooding. Although the FEMA *Flood Insurance Study Guidelines and Specifications for Study Contractors* specifies methods for analyzing ice jam floods, the hydrology typically done for flood insurance studies and most other types of studies is based on clear water flow.

For CRS credit, ice jam hazards must be mapped using either the direct or indirect method of determining ice jam flood elevations as specified in Appendix 3 of the current version of *Flood Insurance Study Guidelines and Specifications for Study Contractors*. This manual can be found at the website http://www.fema.gov/plan/prevent/fhm/dl_scg.shtm.

Example 411IJ-1. In 1996, FEMA mapped North County's floodplains based on new hydrology. The 100-year ice jam flood elevations based on historic ice jam flooding also were determined. This makes North County eligible for special hazards credit under Sections 420SH and 430SH.

2. <u>M</u>apping credit for <u>c</u>losed <u>b</u>asin lakes (MCB):

   There is no 410SH credit for mapping closed basin lake flooding hazards because the *Flood Insurance Study Guidelines and Specifications for Study Contractors* specifies mapping criteria for this hazard. However, this hazard must be mapped in order for the community to receive credit for management of closed basin lake hazards in Section 431SH and/or for credit for preservation of open space in these hazard areas under Section 420SH.

   If the community prepares a new map that includes the closed basin lake mapping technique, it is eligible for regular Activity 410 credit.

3. <u>M</u>apping credit for <u>m</u>ud<u>f</u>low hazards (MMF) (Maximum credit: 50 points)

   (a) Prerequisite: To receive credit for mapping mudflow hazards, the community must either map the hazard areas in detail, or it must require developers to do so as a condition of any development permit. The methods used must be accepted by the FEMA Regional Office.

   (b) MMF credit:

   (1) 50 points, for mapping mudflow or landslide hazards in areas outside the SFHA as shown on the community's FIRM if the scale of the mapping is 1:10,000 or smaller.

   (2) 50 points, for mapping mudflow or landslide hazards in areas inside the SFHA as shown on the community's FIRM if the scale of the

mapping is 1:10,000 or smaller and the regulatory flood elevation is higher than the base flood elevation shown on the FIRM..

(3) 20 points, for mapping mudflow or landslide hazards in areas outside the SFHA as shown on the community's FIRM if the scale of the mapping is larger than 1:10,000.

Mapping areas subject to mudflow hazards requires examination of previous landslides, topography, and soils. No specific method is recommended for CRS credit. Maps from any source that are used by the community for regulatory purposes, as long as they are at an appropriate scale, are acceptable for CRS credit with approval from the FEMA Regional Office.

Example 411MF-1. The state Department of Mining and Geology (DMG) mapped Steep County's mudflow hazards at a scale of 1" = 200' (1:2,400).

MMF = 50.

4. Mapping credit for areas subject to land subsidence (MSU) (Maximum credit: 50 points)

(a) Prerequisites:

(1) To receive CRS credit for mapping areas of land subsidence where subsidence is due to the withdrawal of fluids or gasses, or is associated with organic soils, maps of future subsidence must be provided. The entire floodprone area subject to subsidence must be mapped by methods accepted by the FEMA Regional Office. Credit is provided for mapped floodprone areas where the combination of historic and projected subsidence is greater than 1.0 foot.

(2) If the community is requesting credit for reducing future land subsidence, but not for regulation of development in areas subject to flooding as a result of future land subsidence, mapping of the area subject to future subsidence by methods accepted by the FEMA Regional Office is necessary.

(3) To receive CRS credit for mapping, areas of land subsidence where subsidence is due to the formation of sinkholes, the maps must at least show all existing sinkholes in the community. To receive CRS credit for open space preservation and/or management of land subsidence where subsidence is due to the formation of sinkholes, the maps must include areas where there is a potential for new sinkholes using methods accepted by the FEMA Regional Office.

(b) MSU credit:

(1) MSU credit of 50 points is provided for the area outside the SFHA shown on the community's FIRM that is mapped as subject to subsidence.

(2) MSU credit of 20 points is provided for areas inside the SFHA as shown on the community's FIRM that are mapped as subject to subsidence.

Understanding and mapping land subsidence itself is usually only the first step. Gradual land subsidence subtly changes the land surface so that the flood hazard changes. This is easy to imagine in a coastal situation: if the land is ten feet above sea level, and it subsides eleven feet, it will be below sea level.

It may be more difficult to envision the results of land subsidence at an inland location. Imagine a tabletop model of a river flowing through a broad valley. Now deform the land surface by placing a large bowl or sphere in the middle of the model and pushing it down just an inch or so. When the bowl is removed, the slope at the upper side of the depression is slightly greater, so water flows a little faster. Since the quantity of water is the same, if it is flowing faster, it will not be quite as deep.

However, at the lower side of the depression, the slope is slightly less, so the water will flow more slowly. The water level will be somewhat higher, and the area it covers will be somewhat larger. The deeper the depression, the larger the flooded area. This is what happens to relatively large areas where there is land subsidence. The floodplain gradually increases over time, and the flood elevation relative to the land surface gradually increases.

Therefore, to really understand the flood hazards associated with land subsidence, it is necessary first to map historic land subsidence, then to project future land subsidence, and finally, to map the projected floodplain and future flood elevations.

Example 411SU. In 1999, Flat County mapped the floodplain based on ultimate subsidence and development through the year 2030. At the same time, FEMA hired the County's consultant to map the floodplain under existing conditions. Flat County receives MSU1 = 50 for areas that were outside the SFHA on its 1978 FIRM. It receives MSU2 = 20 for areas that were within the SFHA on its 1978 FIRM.

Managing Subsidence in the Houston Area

The Harris-Galveston Coastal Subsidence District (District) was created in 1975 to regulate the withdrawal of groundwater within Harris and Galveston Counties. The District was created "…for the purpose of ending subsidence, which contributes to or precipitates flooding, inundation, or overflow of the district, including without limitation rising waters resulting from storms or hurricanes."

Since 1976, the District has adopted three regulatory plans. The initial plan focused on having an immediate impact in the area where the most subsidence had taken place and where surface water was available as an alternative to groundwater. The 1976 plan regulated pumpage in all of Galveston County and much of eastern Harris County in an area referred to as the "area of concentrated emphasis."

The 1985 plan divided the District into eight regulatory areas so that subsidence could be addressed throughout the entire District. This plan had an overall goal of changing primary water usage from groundwater to surface water through a series of steps.

The 1992 plan modified the 1985 plan based on a detailed re-analysis of regional population and water demand data. The 1992 plan divided the District into seven regulatory areas with goals for each area to reduce groundwater withdrawal by certain dates. The areas were based on surface water availability, geophysical characteristics, and groundwater demand.

The 1999 regulatory plan divides the District into three regulatory areas. The regulatory areas of this plan have been reconfigured from the 1992 plan to generally reflect converted versus unconverted areas. The requirements contained within the regulatory plan are based on the most current data and studies on water demand, aquifer levels, and projected subsidence, and provide permittees with organizational flexibility in meeting these regulations.

In the most critical areas (closest to the Gulf Coast), water users must limit groundwater use to 10% of their total water use. In the next most critical area, groundwater use is limited to 20% of total water use (Harris-Galveston Coastal Subsidence District, 2001).

Even with these regulatory measures in effect, water levels declined as much as 100 feet during 2002, and land subsidence of up to one foot was measured. Rainfall was above average at most locations in the District (Harris-Galveston Coastal Subsidence District, 2003).

5. Mapping credit for uncertain flow path hazards (MUF) (Maximum credit: 50 points)

   (a) Alluvial fan hazards: There is no credit for mapping alluvial fan hazards. Because the *Flood Insurance Study Guidelines and Specifications for Study Contractors* specifies mapping criteria for this hazard, such mapping is a minimum requirement of the NFIP. However, this hazard must be mapped in order for the community to receive credit for management of alluvial fan hazards in Section 431SH and/or for credit for preservation of open space in these hazard areas under Section 420SH.

If the community prepares a new map that includes alluvial fan hazards, it is eligible for regular 410 credit.

(b) Moveable bed stream hazards:

(1) MUF1: Credit of 50 points is provided for moveable bed streams:

((a)) In the case of aggrading or degrading streams, a sediment transport model is required that includes the availability of sediment to the stream, and that accounts for its movement through the floodplain. Modeling of these streams for CRS credit must look at present conditions and projections of future conditions based upon changes in the source of sediment and the floodplain. Mapping must be based upon the worst case of aggradation or degradation.

((b)) In the case of channel migration, the local history of migration must be reflected in the mapping process. For full credit, mapping must be based upon floodplain soils and historic channel migration that indicate the probable extent of future migration.

(2) MUF2 credit of 25 points is provided for the following requirements when there are no studies that meet the criteria of (a) above.

((a)) In the case of aggrading or degrading streams, for permits for single structures the community may require only a statement from a registered professional engineer that the proposed structure is reasonably safe from the erosion- or sedimentation-related flood hazard.

((b)) In the case of channel migration, credit is provided if a community uses a locally developed standard building setback for unstudied streams in lieu of a detailed study by a developer. Such a setback standard must be based upon data from the general area regulated.

Example 411UF-1.

Arid County mapped the West River as a stream with a migrating channel and Dry Creek as a stream with a degrading channel. These studies were also adopted by the County Commission in 1997.

Arid County requests CRS credit for MUF2a and MUF2b.

Mapping Alluvial Fans: Since the *Guidelines for Determining Flood Hazards on Alluvial Fans* (FEMA, 2000) prescribes methods for mapping alluvial fan hazards, mapping alluvial fan floodplains is a minimum requirement of the NFIP. Therefore, there is no CRS credit for such mapping. Although there is no CRS credit for mapping alluvial fan hazards, these hazards must be mapped before other CRS credit can be verified for management of these hazards.

Although the *Guidelines* prescribe mapping methods for alluvial fans, active support is generally needed by the community to get such mapping included on the community's Flood Insurance Rate Map. This is because alluvial fan mapping must generally be accompanied by specific ordinance language.

If a community has alluvial fan hazards, it should seriously consider appropriate mapping and management of these hazards.

Mapping Degrading Stream Reaches: Mapping degrading stream reaches for management purposes is relatively simple. As the channel degrades, the inundated area shrinks until it is contained within the degraded channel. Unless the stream banks become unstable and the channel migrates, errors will generally be on the safe side, since the areal extent of the flood hazard is either stable or becoming smaller. There are no known maps used for floodplain management purposes that account for channel degradation, although local studies of degradation and scour have been performed in many communities.

The objective when mapping degrading stream reaches is to identify the location and progress of the degradation process so that facilities in and immediately adjacent to the channel can be designed to be safe from the ongoing degradation.

Mapping Aggrading Stream Reaches: In areas where aggradation is suspected or has occurred during historic flooding, it is expected that the channel is losing capacity, the floodplain is getting wider and flood elevations are getting higher. These are the problems to be addressed by mapping. The result may be similar to mapping floodplains based on future-condition hydrology for developing watersheds.

Mapping Reaches Subject to Channel Migration: In stream reaches where the channel may migrate outside the 100-year floodplain as defined by fixed-bed modeling, the establishment of setbacks from the channel banks based on historic channel migration may take the place of more rigorous mapping techniques. This approach requires a developer to perform a detailed study of the channel morphology before developing inside the setback.

> **Example.** In King County, Washington, a mapping process similar to that in Arizona was used to map a migrating channel. In a study of the Green River, the effect of sediment transport throughout most of the reach was related to locations of channel migration, rather than ongoing aggradation or degradation. Delineation of "probable unconstrained limits of channel migration" was based primarily on historic data. The "mitigated hard area" was

then delineated assuming that ongoing protection would be provided for major roads, subdivisions and levees in the floodplain.

Example. Pima County, Arizona applies a construction setback of 500 feet from the channel bank of specified major streams, 250 feet for streams where the 100-year flow is more than 10,000 cfs, 100 feet for streams with 100-year discharges greater than 2,000 cfs, and 50 feet for streams with 100-year discharges greater than 100 cfs (Cella Barr Associates, 1987). These setbacks are based on the experience of the Pima County Flood Control District. Pima County also used recent and historic aerial photos and old land survey notes to more precisely determine setback limits for the Rillito River in and near Tucson, Arizona. Exceptions are made where there is bedrock or other impediment to channel migration, where there is bank protection provided, or where an engineering study indicates that the channel will not migrate.

Example. The State of Arizona developed a similar standardized approach that is applied statewide. It establishes a setback for all streams based on the 100-year flow, the curvature of the channel and other parameters. This approach has been implemented by Arizona communities as a minimum standard.

412SH Credit Calculation

cAFDSH = cMMF + cMSU + cMUF

413SH Credit Documentation

The documentation required for special hazards mapping credit must show how the mapping addresses the special hazard mapping criteria described in this section.

The community must provide the following:

a. A map that shows the areas subject to the special hazards and the other floodplains (including the SFHA) in the community. If only a small area of the community is mapped for special hazards, only the SFHA in that area need be shown on the map.

b. A description of the method used for the mapping that shows that it reasonably delineates areas subject to the special hazards, along with documentation that the method is acceptable to the FEMA Regional Office.

c. Credit for 410SH is only provided if the mapping is used for land use regulation to prevent damage from the special hazard. The documentation required for Activity 430SH will suffice for this prerequisite.

414SH For More Information

The following publications may be obtained from

FEMA Distribution Center
P.O. Box 2010
Jessup, MD 20794-2012
1-800-480-2520
Fax: (301) 362-5335

Guidelines and Specifications for Flood Hazard Mapping Partners, FEMA-37, February 2002. http://www.fema.gov/plan/prevent/fhm/gs_main.shtm

Alluvial Fan Guidelines, FEMA, February 2000. http://www.fema.gov/pdf/fhm/ft_afgd.pdf

Arizona State Standard for Watercourse System Sediment Balance, Arizona Department of Water Resources, Phoenix, AZ, 1996. http://www.azwater.gov/dwr/Content/Find_by_Program/Dam_Safety_and_Flood_Mitigation/Floodplain_Managment_Docs/SS5-96_System_Sediment_Balance.pdf

Maricopa County, Arizona, floodplain management regulations. http://www.fcd.maricopa.gov/Services/FloodplainRegulations.asp

420SH Open Space Preservation in Special Hazard Areas

NOTE: This section is a supplement to Activity 420 (Open Space Preservation) in the *Coordinator's Manual*. Much of the discussion in this section relies on Activity 420. Please read that section before proceeding.

One of the best ways to prevent flood damage is to keep floodprone areas free from development. In addition to the flood protection benefits, preserving open space can greatly enhance the natural and beneficial functions that floodplains serve. For CRS credit, "open space," means that the land must be free from buildings, pavement, fill, or other encroachments to flood flows.

In areas subject to special flood hazards, preservation of open space may be the single most important tool for protection of future development.

For example, there are two hazards associated with ice jam flooding: higher flood elevations when ice plugs the channel and/or floodplain; and the movement of ice floes. The elevation hazard can be mitigated by elevating or floodproofing buildings. The movement of ice floes may be difficult or impossible to mitigate with construction methods (see photo on page 5), and preservation of areas subject to this hazard as open space may be the only sure way to mitigate the hazard.

In areas adjacent to closed basin lakes, the primary cause of flood damage is the duration of flooding. There may be areas at the edge of this hazard that can be developed with special attention to access and utilities, but inside this area, preservation of open space may be the only viable means of mitigating the hazard.

This activity provides credit for having floodprone property within a designated special hazard area preserved as publicly owned or controlled open space. This credit is in addition to the credit provided for open space (OS) in Activity 420.

All of the requirements of Activity 420 apply to 420SH credit. In addition, areas for which this credit is provided must be mapped as areas subject to special hazards as discussed in Section 410SH.

421SH Credit Points

Special hazard area preserved as open space (SHOS) (Maximum credit: 50 points)

a. Prerequisites: Up to 50 points are provided if at least five acres of the regulatory floodplain meets two prerequisites:

   1. The area must be eligible for credit for open space preservation as discussed in Activity 420; and

   2. The area must be designated as an area subject to special hazards in a study that is credited under Activity 410SH.

This requirement may be met in one of three ways:

1. Public land such as state and local parks and easements: However, as noted in Section 403 of the *Coordinator's Manual*, there is no open space credit for federal lands. All portions of city and county parks, forest preserves, state parks and state forests, publicly owned beaches, or natural areas that are within the regulatory floodplain may be counted for open space credit. Separate parcels owned by a school district or other public agency can be counted, provided there are no buildings on them within the regulatory floodplain.

2. Preserve land: private wildlife or nature preserves that are maintained for open space purposes. Examples would be church retreats, hunting club lands, Audubon Society preserves, and similar privately owned areas that are set aside and not intended to be developed. A parcel set aside by a developer as a temporary "preserve" until the area develops is not considered permanent open space.

3. Restrictive development regulations: privately owned lands subject to state or local regulations that prevent construction of buildings or the placement of fill or other obstructions. Credit is only given for such regulated lands that are vacant at the time of application for CRS credit. Some examples are setback regulations, natural areas regulations, or any state or local law that prohibits new buildings from a defined area. The regulations must also prohibit fill, grading, or other obstructions to flood flows.

Example 421UF-1.

Arid County mapped 212 acres of the Oriental Fan as "Active Alluvial Fan Area" and prohibits structures and fill within those areas. These areas were not developed when the mapping was done. There is also a 565-acre County park preserve in the AO zone.

Since the prohibition of structures and fill in undeveloped areas of the Oriental Fan and West River qualify for credit for preservation of open space (OS) in Activity 420, both of these areas are eligible for UFOS credit.

This gives a total of 777 acres of open space in uncertain flow path hazard areas.

422SH Impact Adjustment

a. Option 1: If the entire area of the special hazard is preserved as open space, the impact adjustment, rSHOS, is 1.0.

b. Option 2: If five or more acres of the special hazard area is preserved as open space, the impact adjustment, rSHOS, is 0.2.

c. Option 3: Where more than 20% of the special hazard area is preserved as open space, the community may calculate an impact adjustment by dividing the special open space area (aSHOS) by the area of the mapped special hazard (aSH).

$$rSHOS = \frac{aSHOS}{aSH}$$

423SH Credit Calculation

> Maximum credit for special hazard open space is 50 points.
>
> cSHOS = SHOS x rSHOS

424SH Credit Documentation

> The community must provide the following:
>
> a. The community must receive credit under 410SH.
>
> b. Documentation that the area where open space credit is requested is in the special hazard area and meets the open space requirements of Activity 420 (Open Space Preservation) in the *Coordinator's Manual*.

430SH Higher Regulatory Standards for Special Hazards

431SH Credit Points

NOTE: *This section is a supplement to Activity 430 (Higher Regulatory Standards) in the* ***Coordinator's Manual****. Much of the discussion in this section relies on Activity 430. Please read that section before proceeding.*

In areas where it is not feasible to restrict land to open space uses, other land use planning measures can be used to minimize flood damage. These include strategically controlling the type of development and uses allowed in hazard areas, and avoiding high-value and high-occupancy uses as much as possible. For example, plan designations and zoning districts can use density restrictions or large-lot zoning to ensure that only very low density residential uses are allowed in hazard areas.

Credit is provided for regulating special hazard areas in a manner that recognizes those elements of the hazard not addressed by the NFIP minimum standards for floodplain management. This credit is in addition to credit provided for other regulatory standards under Activity 430 in the *Coordinator's Manual*.

> Maximum credit for Activity 430SH: 100 points.
>
> a. Prerequisites for credit for 430SH:
>
> 1. The community must have received credit for mapping areas subject to special hazards under Section 410SH, except for ice jam hazards, closed basin lakes, and alluvial fan hazards, which must have been mapped

according to the *Guidelines and Specifications for Flood Hazard Mapping Partners.*

2. The community must adopt and enforce regulatory standards that address the special risks associated with these hazards.

b. Regulation of special hazard areas (SHR)

1. Ice jam regulations (IJR) (Maximum credit: 100 points) Credit for IJR is the sum of the following:

   (a) 50 points, for requiring new structures to be constructed on engineered fill or engineered pilings at or above the ice jam regulatory flood elevation;

   (b) 12 points x freeboard above the ice jam regulatory flood elevation (in feet) (maximum credit = 36 points for 3 feet of freeboard); and

   (c) 14 points for prohibiting new structures in areas subject to ice floe damage (this is in addition to credit for open space preservation).

Regulation of areas subject to ice jam flood hazards should include protecting buildings from both the hazard from higher flood elevations and the hazard associated with moving ice floes. These regulations may include higher minimum floor elevations and structural requirements for buildings so that they are not damaged or destroyed by moving ice. There may also be special requirements for infrastructure in areas subject to ice jam hazards.

Land development criteria, such as clustering the buildings in a development to keep them out of the area subject to ice jam hazards, and low density zoning, which reduces the development potential in the ice jam hazard area, also reduce the damage potential.

Example 431IJ.1. North County prohibits development in the reach of the floodway affected by ice jam flooding. IJR1 = 50 + 14 = 64. In the reaches regulated for ice jam hazards outside the floodway, IJR2 = 50.

2. Closed basin lake hazards regulations (CBR) (Maximum credit: 100 points) Credit for CBR is the sum of the following:

   (a) 60 points, if new structures are required to be built on fill at or above the regulatory flood elevation for closed basin lakes credited in 410SH;

   (b) 10 points, if access is required at the regulatory flood elevation;

   (c) 10 points, if all utilities are required to be protected to the regulatory flood elevation and functional during the regulatory event;

(d) 15 points, if all utilities and basements within 1,000 feet of the shoreline established by the regulatory flood elevation are required to be floodproofed to the regulatory flood elevation unless it can be demonstrated that the water table under the proposed development will not be affected by lake elevations; and

(e) 5 points, if new wells constructed within the hazard area are required to be floodproofed to the regulatory flood elevation, and all existing wells that are to be abandoned are required to be sealed to eliminate the mixing of groundwater and lake water.

CRS credit for regulation of areas subject to closed basin lake flood hazards should anticipate both the flood elevation and the long duration of high water surface elevations. It is important to protect utilities and infrastructure from long periods of inundation and to ensure access to buildings at the highest anticipated lake level. There is credit for land development criteria that reduce development adjacent to closed basin lakes, such as density trades, and for low density zoning in these areas.

Example 431CB. Lake City requires buildings on land between 1,010 feet and 1,012 feet msl to be elevated on fill to 1,012 feet. No septic tanks or wells are allowed in areas where the land elevation is below 1,012. CBR = 85.

3. Mudflow hazard regulations (MFR) (Maximum credit: 35 points): Credit for MFR is the sum of the following:

(a) 25 points, if a study by a soils engineer and/or an engineering geologist is required for any hillside grading where stability will be lessened by the grading, and at historic or prehistoric landslide sites;

(b) 5 points, if where buildings are to be supported on stilts over a fill slope with a slope greater than two horizontal to one vertical, footings must extend at least 3 feet into the underlying bedrock, but not less than the depth required to resist the lateral load; and

(c) 5 points, if drainage from impervious surfaces must be collected and conducted to the street in a non-erosive manner.

There is no safe way to develop an area that is subject to mudflow hazards. However, maps of mudflow hazard areas are usually based on relatively large-scale map analysis, so most regulations require an engineering study, a geologic study, or both. The idea is that some of the area mapped as mudflow hazard may actually not have such a hazard, but it is the developer's responsibility to determine the true hazard.

4. Land subsidence hazards:

   (a) Land subsidence regulations (SUR1) (Maximum credit: 100 points): Credit is provided for regulating development in the floodprone areas subject to land subsidence based upon the regulatory flood elevation considering projected subsidence as determined in accordance with the criteria of Section 411SH. Credit for SUR is the sum of (1) and (2):

      (1) 80 points, if all new buildings must be built on engineered foundations with pilings that will prevent the building from sinking as subsidence continues.

      (2) 20 points, if all new public facilities and utilities are required to be designed for the subsidence hazard.

   (b) If the community does not apply for regulation of development (SUR1) under the above section, credit is provided for activities intended to reduce future land subsidence. If the community has mapped current subsidence, and if that subsidence is greater than 1.0 foot, and if the community has a scientific plan to reduce future subsidence, SUR2 = 50.

Regulation of the activities that cause subsidence is the most direct approach to subsidence mitigation. Approaches to prevent or control subsidence vary according to the type of subsidence. In the case of resource extraction, they range from banning extraction to controlling how materials are removed. In the case of land development practices that cause subsidence, they range from banning development to regulating construction practices.

Different causes of subsidence require different regulatory approaches for controlling the subsidence. For example,

- If land subsidence is a result of aquifer compaction, then changes in the amount of groundwater extracted and/or perhaps the locations at which it is extracted, may be required to reduce or eliminate subsidence. This is a difficult choice to make when groundwater is needed to support existing and projected land uses. State or federal funding may be required to provide alternate sources of municipal, industrial, and agricultural water, and multiple jurisdictions may have to work together to control land subsidence.

- If land subsidence is due to the dewatering of organic soils, controlling the water table by extensive pumping may have to be combined with extensive levee systems if the land is to be used and the subsidence controlled.

- If land subsidence is caused by the dissolution of soluble subsurface materials, any subsurface movement of water makes the problem worse. Extraction or recharge of groundwater may accelerate the natural processes that cause sinkholes or more gradual land subsidence.

The local causes of land subsidence must be understood before regulatory standards can be applied. Where subsidence is gradual and ongoing, land use regulations may be effective in reducing flood damage. If the relatively constant rate of subsidence in an area is known, new development can be prohibited or elevated to compensate for predicted future subsidence. If the probability of subsidence (like sinkholes) is not uniform over an area, low density zoning may reduce the damage in the areas with highest risk. Again, the cause of land subsidence, combined with some ability to predict future subsidence, is required.

5. Uncertain flow path regulations (UFR) (Maximum credit: 100 points): A community may receive credit for regulation of areas subject to four types of uncertain flow path hazards: alluvial fans, aggrading stream channels, degrading stream channels, and migrating stream channels. Credit for only one type of uncertain flow path hazard is allowed in a particular area. For each stream reach or area, the community should seek credit for the one that gives the highest credit for UFR.

   (a) Credit is provided for regulating development in areas subject to alluvial fan hazards that account for the flood, sediment, erosion, debris, velocity, and avulsion hazards in the area. For alluvial fans, credit for UFR1 is the sum of the following:

      (1) 80 points, if all new structures are required to be protected from alluvial fan hazards;

      (2) 10 points, if all utilities are required to be designed to function and minimize damage during the 100-year event; and

      (3) 10 points, if access is required during the 100-year event.

   (b). Credit is provided for regulating development in areas subject to moveable bed stream hazards that have been mapped in accordance with the criteria of Section 411UF.a.

      (1) In the case of aggrading streams, UFR2 credit is provided for management of future development to the UFR2 flood elevation. The minimum area to be regulated must be the area inundated by that flood. UFR2 credit is the total of the following:

         ((a)) 50 points, if new residential structures are required to be elevated to the regulatory flood elevation;

         ((b)) 20 points, if new non-residential structures are required to be elevated or floodproofed to the UFR2 flood elevation;

         ((c)) 20 points, if public improvements and utilities are required to be protected from the UFR2 flood elevation; and ((d)) 10 points, if protection is required to at least 1 foot above the UFR2 flood elevation. This credit is in addition to appropriate FRB credit in Activity 430.

(2) In the case of degrading streams, UFR3 credit is given for management of future development within the floodplain inundated by the worst case of the base flood (probably the present channel condition) and to the regulatory flood elevation. Channel developments would be regulated based upon the channel condition during that worst-case flood. UFR3 credit is the total of the following:

((a)) 50 points, if new structures within 200 feet of the banks are required to have engineered foundations; and

((b)) 50 points, if public improvements and utilities within the floodplain are required to be designed to withstand the worst-case base flood and channel conditions.

(3) In the case of streams subject to channel migration, UFR4 credit is provided for appropriate management of future development in the stream reaches subject to channel migration. UFR4 credit is:

((a)) 100 points, if a detailed study of the migration potential has been mapped, and if all public and private developments are required to be located and designed to be safe from channel migration; or

((b)) 50 points, if a standard setback is mapped, and all public and private development is permitted only after a detailed study of the channel migration hazard.

Credit for the three types of moveable bed streams is mutually exclusive, and exclusive of alluvial fan areas. If the mapping process indicates that the nature of the stream changes over time (for example, the channel degrades for a period and then aggrades over another period), the community must demonstrate that its regulation addresses the "worst case" of flood hazard over the entire period.

"Worst case" for purposes of this element means the worst hazard over the period of the mapping study. If, for example, a stream is shown to be aggrading, the worst case might be a combination of unstable vertical banks today, requiring a setback, and a higher flood elevation in the future, requiring higher floor elevations. In the case of a degrading channel, the worst case is the present flood elevation and future unstable banks or channel migration.

Management of flood hazards on alluvial fans requires more than a knowledge of the existence and extent of the fans. The management techniques used at a particular location on a particular fan should be appropriate for the hazards (depth, velocity, and sediment and debris load) at that location. Within a small area, such as a county, fans may be similar enough to manage under a single set of standards, but these standards must be carefully developed.

Neither *Alluvial Fan Flooding* (National Research Council, 1996) nor *Guidelines for Determining Flood Hazards on Alluvial Fans* (FEMA, 2000) suggest much in the way of regulatory standards. In a discussion of several specific alluvial fans, the former has recommendations such as "avoidance of the hazard" and "only major structural controls will be effective because development is along the entire lower portion of the active fan." For the Carefree Fan in Maricopa County, Arizona, the suggested mitigation is "low-density development with restriction of structures to the stable ridges . . . and elevation of structure floors."

Mitigation of flood hazards on alluvial fans must respond to three components of the hazard: velocity of the water, sediment, and debris; the volume and movement of sediment and debris during floods; and the potential for channel migration across the fan during flood episodes (avulsions). All of these components are present where there are no confined channels. Where there are confined channels, only the first two components of the flood hazards exist.

Example. Maricopa County, Arizona, has two separate management schemes for "active" and "inactive" fan areas. Inactive fan areas are designated as unnumbered A Zones, and development is required to be elevated two feet above grade. Active fan areas are designated as "Administrative Floodways," with management similar to that required by the NFIP for floodways

From the "Floodplain Regulations for Maricopa County" as amended November 2000:

Section 1301. Development in Alluvial Fan Zone A.

1. *Where alluvial fans have been designated using the District's Piedmont Assessment Manual, the following shall apply:*
   a. *Development within an Alluvial Fan High Hazard Area, Alluvial Fan Uncertain Flow Distribution Area and Alluvial Fan Floodway shall be regulated in a manner similar to a floodway. Only major engineering measures as outlined in 44 CFR 65.13 can be used to mitigate the alluvial fan flood hazard in these areas*
   b. *Development within an Alluvial Fan Zone A (AFZA) shall be regulated in a manner similar to a Zone A riverine floodplain. Development may require an engineered plan.*

Example. Pima County, Arizona, has identified a 154-square-mile area as the Tortolita Watershed, consisting of the mountainous headwaters and sediment source and the associated alluvial fans. The following standards were recommended for application throughout the watershed (Cella Barr Associates, 1987):

- Washes with a 100-year peak flow in excess of 1,000 cfs should be maintained as natural undisturbed riverine environments, and detention facilities should not intercept them;
- The basin is designated as a “critical” basin, so development must decrease existing runoff;
- Drainage maintenance plans are required for developments that exceed 40 acres in the upper watershed or 120 acres in the lower watershed, or if they contain or abut a major wash or propose major channel modification;
- Rezoning densities should be maintained at or below those specified in a County-developed area plan (1.21 to about 2.70 residences per acre);
- Sedimentation should be considered in drainage studies; and
- Floodway surcharges and post-development velocities are limited.

Example. Whatcom County, Washington, has mapped alluvial fans as one of several geologic hazards. The ordinance states, “No critical facilities shall be constructed or located in geologically hazard areas without fully mitigating the hazard.” Also, “All projects on an alluvial fan must be engineered and constructed to withstand alluvial fan hazards and/or flooding equivalent to the largest known event evident on the fan as determined by professional assessment” (Whatcom County, 1997).

Regulation of Areas Subject to Moveable Bed Streams

The management needs are somewhat different for the three types of moveable bed streams, so they are discussed separately.

Example. In the State of Washington, the State Department of Ecology has developed the *Stormwater Management Manual for Western Washington* (Washington Department of the Environment, 2001) to maintain current levels of peak flow and sediment for all floods up to the 100-year event as a means of protecting its fisheries. This manual will ultimately apply to all Washington communities between the Cascade Mountains, the Puget Sound, the Pacific Ocean, and the Columbia River. Regulation of sediment transport throughout the watershed should allow the watercourses to come into equilibrium, minimizing future erosion, sedimentation, and channel migration.

Areas Subject to Degradation—In stream reaches that are subject to channel degradation, the greatest potential threats are to development in the channel (including sand and gravel operations and public recreation facilities) and infrastructure in and adjacent to the channel (including flood control projects, roads, bridges, and buried utilities). If the channel degradation does not cause instability in the banks, protection of these facilities may be managed by construction standards and special use permits that recognize the hazards. If the banks are unstable, setbacks may also be needed. No regulations have been found that specifically address the increased future hazards associated with degrading streams.

Regulation of sand and gravel operations may be extremely important in some locations to control channel degradation but, to be effective, such regulation would have to be based on the kind of comprehensive modeling approach described by the State of Arizona. If a sand and gravel pit is located where floodwater can enter it, it may act as a sediment trap, allowing sediment to settle out. When the water leaves the pit, it is free of sediment, and immediately scours the bed downstream to restore its sediment load. Water entering the pit may also cause headcutting upstream from the pit. Detailed sediment transport studies are usually required to determine the effects of sand and gravel pits in floodplains, particularly in floodways.

Example. Maricopa County, Arizona, has adopted a regulation specifically for sand and gravel operations. It states:

> A Floodplain Use Permit for the extraction of sand and gravel or other materials within the Floodway shall be granted if the applicant shows that excavations will not have cumulative adverse impact nor be of such depth, width, length, or location as to present a hazard to life or property or to the watercourse in which they are located and that they will comply with any applicable Watercourse Master Plan adopted by the Board of Directors… Excavations shall not be permitted so close to any floodway crossings, utility structures or facilities as to cause or have the potential to cause an adverse effect on such crossings, utilities or similar facilities... A plan of development shall be submitted with an application for a Floodplain Use Permit to the Floodplain Administrator. The Floodplain Administrator will determine whether an engineered plan will be required and whether a sediment transport analysis is necessary… The plan of development shall be required to include a plan of reclamation to leave the land when the approved use is terminated in such a condition as to maintain stability of the floodway by backfilling, contouring, leveling, removal of equipment and materials or other appropriate means… The plan of development is subject to post-flood review and possible modification if necessary due to flood related changes in river morphology."

Areas Subject to Aggradation—Aggrading stream reaches cause more flood damage in both the channel area and the overbank area than those expected if the reach is delineated using a fixed-bed model. In Maricopa County, Arizona, aggradation in the channel of the Gila River caused a 100-year flood to inundate the 500-year floodplain in 1980. The old primary river channel, choked with vegetation watered by sewage effluent, was filled with silt and a new channel was cut up to 1,500 feet away.

Management of aggrading stream reaches should account for the ongoing loss of channel and/or floodplain conveyance capacity and the resulting increase in future flood elevations and larger areal extent of flooding in future events.

No regulations have been found that specifically address the increased future hazards associated with aggrading streams. Setback lines and freeboard requirements provide some mitigation for these hazards, but if they are to provide true mitigation, they need to be based on a detailed study that forecasts future flood elevations and floodplain limits. Such studies may be included in mapping projects that are based on future-conditions hydrology.

Areas Subject to Channel Migration—In stream reaches where there is a history or geologic evidence of channel migration, floodplain management to reduce future flood damage must consider the possibility of future channel migration.

Example. King, County, Washington, has established setback lines along at least one river based on a study of historic and potential channel migration.

Example. Pima County and Tucson, Arizona, have established setback lines along all watercourses based on recent experience and an examination of selected floodplains. In Pima County, a developer must provide a detailed study, including a sediment transport analysis, in order to develop inside the setbacks. Setbacks range from 50 feet on minor washes to as much as 500 feet. The setback is from the channel bank or the 100-year floodplain, whichever is wider (Pima County, 1999).

Example. In San Diego County, California, a Resource Protection Ordinance requires a setback of 100 feet or 15% of the floodway width, whichever is less, from the floodway boundary. Where erosion/sedimentation hazards are identified, no development is allowed. Also, the floodway is established using a maximum increase in flood elevation of 0.2 feet, and floodways are limited to velocities of 6 feet per second flood, which increases the floodway width in many steep floodplains. Although it is not quantifiable, these floodway restrictions should provide more protection than floodways delineated using the standard FEMA criteria of an allowable 1.0 foot rise with no consideration of velocity.

Example 431UF-1.

In the Oriental Fan area, the mapping study upon which Arid County's regulations are based produced elevations based on water, sediment, and debris. Flood velocities are estimated throughout the area. New development must be designed to protect against these hazards. UFR1a = 80.

In the West River floodplain, the County adopted a setback line and prohibits new buildings and fill within this area. This regulatory standard is credited in Activity 420UF.

Adjacent to Dry Creek, which is a degrading channel, the County requires all new buildings to have engineered foundations. UFR3a = 50. Public improvements and utilities within the floodplain are required to be designed to withstand the worst-case base flood and channel conditions. UFR3b = 50.

432SH Impact Adjustment

> The area affected by the special regulations must exclude areas designated as open space that are receiving Open Space (OS) credit under Activity 420 (Open Space Preservation).
>
> a. Option 1:
>
> 1. If new development within the entire area of the special hazard is subject to the regulations, and no credit was requested for SHOS in Section 420SH, the impact adjustment rSHR is 1.0
>
> 2. If new development within the entire area of the special hazard is subject to the regulations, and credit was requested for SHOS in Section 420SH, the impact adjustment rSHR = 1.0 – rOS.

As with other regulatory elements, areas for which open space credit (Activity 420) is requested must be excluded from the area credited for the special regulations.

> b. Option 2:
>
> If the special regulations cover only a portion of the special hazard area, rSHR = 0.25.
>
> c. Option 3:
>
> If the special regulations cover more than 25% of the special hazard area, the impact adjustment ratio may be computed by dividing the area affected (aSHR) by the area of the mapped special hazard (aSH). Any area for which SHOS credit is requested must be excluded from the element's area measurements.
>
> $$rSHR = \frac{aSHR}{aSH}$$

432SH Credit Calculation

a. cIJR = IJR x rIJR

b. cCBR = CBR x rCBR

c. cMFR = MFR x rMFR

e. cSUR = SUR x rSUR

e. cUFR = UFR x rUFR

f. cSHR = cIJR + cCBR + cMFR + cSUR + cUFR + cLZSH

The value for cLZSH is found in Section 433LZSH.

The value of cSHR is added to SHR in Activity 430.

The maximum credit for cSHR is 150 points, so if cSHR is greater than 150 points, cSHR = 150.

433SH Credit Documentation

The community must provide the following documentation:

a. The state or local law or ordinance language that adopts the regulatory standard. The acronym SH must be marked in the margin of the sections of the ordinance that apply to this activity.

A photocopy of the appropriate pages of the ordinance is sufficient and should be attached to the activity worksheet. The Chief Executive Officer's application certification is considered to include a certification that the ordinance or statute has been enacted into law and is being enforced (see Section 212.a in the *Coordinator's Manual*).

The community must have the following documentation available to verify implementation of this activity:

b. An explanation of the procedures followed for enforcement.

The ISO/CRS Specialist will ask to see permit records for development in the special hazard area to verify that the regulations are enforced.

430LZSH Low Density Zoning in Special Hazard Areas

Credit is provided for zoning areas to keep them substantially open. This credit is available for undeveloped land within low density zoning districts, as well as for areas developed in accordance with the density requirements.

431LZSH Credit Points

Areas subject to special hazards with low density zoning (LZSH) (Maximum credit: 50 points):

Within the areas subject to special hazards, credit is provided for low density zoning.

Credit is given for those portions of the mapped special hazard area that are subject to zoning rules that require a minimum of 1 acre per building or unit. Maximum credit is provided for a 10-acre or larger lot size.

s = the minimum lot size in acres.

LZSHs = 5 x s, for areas with special hazards and with minimum lot sizes of at least 1 acre.

The credit for low density zoning is based upon the traditional zoning approach of setting minimum lot sizes for different zoning districts. The bigger the lot size, the less dense the development will be in the special hazard area.

432LZSH Impact Adjustment

The area affected by the low density zoning regulation must exclude areas designated as open space that are receiving Open Space (OS) credit under Activity 420 (Open Space Preservation).

a. Option 1:

1. If new development within the entire area of the special hazard is subject to low density zoning regulations, and no credit was requested for SHOS in Section 420SH, the impact adjustment rLZSH = 1.0

2. If new development within the entire area of the special hazard is subject to low density zoning regulations, and credit was requested for SHOS in Section 420SH, the impact adjustment rLZSH = 1.0 – rOS.

As with other regulatory elements, areas for which open space credit (Activity 420) is requested must be excluded from the area credited for low density zoning.

b. Option 2: The community may use the default value if its low density zone covers at least 5 acres of the special hazard area. rLZSH = 0.2.

The use of Option 2 is limited to one zoning density for at least 5 acres. Communities with more than 20% low density zoning within their special hazard area may find Option 3 provides more credit.

c. Option 3:

The impact adjustment ratio for each low density zoning district is computed by dividing the area affected (aLZSHs) by the area of the mapped special hazard (aSH). Any area for which SHOS credit is requested must be excluded from the element's area measurements.

$$rLZSHs = \frac{aLZSHs}{aSH}$$

If there is more than one low density zoning district within the special hazard area, each must be appropriately designated on the Impact Adjustment Map (see Section 403) and the area of each must be determined in order to calculate the impact adjustments.

433LZSH Credit Calculation

Maximum credit for special hazard low density zoning is 50 points.

$$LZSH = \sum(LZSHs \times rLZSHs)$$

434LZSH Credit Documentation

> The community must submit the following:
>
> a. The ordinance language that adopts the low density zoning standard. The appropriate acronym(s) (LZSH1, LZSH5, etc.) must be marked in the margin of the sections that pertain to the element.

A photocopy of the appropriate pages of the ordinance is sufficient. The CEO's certification of the application or modification is considered to include a certification that the ordinance or statute has been enacted and is being enforced (see Section 212.a).

> The community must have the following documentation available to verify implementation of this activity:
>
> b. The Impact Adjustment Map prepared in accordance with Section 403 must be provided. Each area listed in Section 431LZSH for which credit is being requested must be designated on the Impact Adjustment Map and in the map's key.

Areas subject to low density zoning are designated as "LZSHs" on the Impact Adjustment Map (see Section 403), where the "s" designates the minimum lot size (in acres). An area of 5-acre zoning would be designated "LZSH5"; an area in which one structure is allowed on a 100,000-square-foot lot would be designated "LZSH2.3" (100,000 square feet is 2.30 acres).

> c. An explanation of the procedures followed for enforcement of the regulatory standard.
>
> d. Examples of developments constructed in accordance with the ordinance language.

During the verification visit, the ISO/CRS Specialist will need to see site plans and final plats that will document how the land development criteria or zoning density is applied. The ISO/CRS Specialist will also visit a sample of new developments to verify that they have been constructed in accordance with the approved plans.

440 Flood Data Maintenance

Any special hazard areas should be included in the community's flood data. If the community has a GIS system used for floodplain management, all special hazards should be included in this system.

CRS credit (8 points) is provided for including special flood-related hazard areas in a geographic information system (GIS), in a digitized parcel system, or on an overlay map. This is found in Section 441.a.2(g) of the *Coordinator's Manual.*

450 Stormwater Management

Although no specific credit is provided in this activity for special hazards, some items credited in the stormwater master plan (SMP) may relate directly to these hazards. For example, in Activity 420, Example 421UF.1, Arid County receives open space credit because it prohibits development or fill in areas that are designated "active alluvial channels." In Section 451.b of the 2002 *CRS Coordinator's Manual*, SMP credit is provided:

> (d) 15, if the plan identifies existing wetlands or other natural open space areas to be preserved from development to provide natural attenuation, retention, or detention of runoff.
>
> (e) 10, if the plan prohibits development, alteration, or modification of existing natural channels.
>
> (f) 10, if the plan requires that channel improvement projects use natural or "soft" approaches rather than gabions, rip rap, concrete, or other "hard" techniques.

Arid County's regulatory requirements for the Oriental Fan area should qualify for all of these credit points because the regulations were adopted as a result of the hydrologic study performed by the Flood Control District for the floodplain management master plan.

500 Flood Damage Reduction Activities

510 Planning

Reducing the risk of damage from natural hazards has always been part of local planning and policymaking. By incorporating hazard information in a comprehensive plan, the local government can provide a sound basis and justification for those approaches that it decides to pursue in managing development and post-disaster reconstruction. Local governments have traditionally responded to natural hazards by delineating hazardous areas and by establishing land use controls, construction standards, and public investment policies governing development within those areas.

Planning tools are designed to guide land use and development patterns while assuring public safety and infrastructure services. Some states have established a planning framework for local governments that sets guidelines for local plans. Some encourage or require local governments to develop their own land use and development plans either for the entire community or for specifically defined resource management areas.

The causes of these special hazards, their locations, and the nature of the hazards make master planning an almost essential element of mitigation of the hazard. Consider that

- Ice jams tend to recur in the same locations;
- The hazards associated with closed basin lakes are due to their long duration of flooding;
- The locations of mudflow hazards can be mapped. If hazard maps are available for a community at a usable scale, they should be incorporated into the community's land use plan, hazard mitigation plan, etc.;
- Relatively large areas are affected by land subsidence, and the hazard develops over a long time period. Even in the case of sinkholes, which may appear suddenly, the causes of subsidence have been present for decades; and
- In areas subject to alluvial fan flooding, better floodplain maps may result from the use of watershed master planning, since seemingly minor obstructions or diversions at critical locations on alluvial fans may cause significant changes in the locations and quantities of downstream flows.

A combination of floodplain management and watershed management under a unified plan may be implemented to mitigate each of these special hazards.

510 Floodplain Management Planning

Communities are encouraged to prepare and adopt floodplain management plans that guide land use development, redevelopment, post-disaster recovery, and mitigation decisions. Credit for preparing, adopting, implementing, evaluating, and updating such a plan could be credited under Activity 510 (Floodplain Management Planning).

Section 511.a.4(b) of the *Coordinator's Manual* provides extra points for a discussion of all special hazards that affect the community.

520 Acquisition and Relocation

As in riverine areas, acquisition and relocation of some structures may be the only viable way to reduce flood damage associated with these special hazards.

The technical feasibility of moving both small and large structures has been demonstrated on several occasions. Moving one- and two-story residential buildings has proven particularly cost-effective for readily movable structures.

Under current policy, if an insured building is damaged by a flood and the state or community declares the building to be substantially damaged, the NFIP may provide assistance to help pay to relocate the structure, up to a maximum benefit of $30,000. This is in addition to coverage for repair of physical damage from flooding.

If there are structures in areas of uncertain flow path flooding that pose a danger to the occupants, or are repetitively flooded, acquisition and relocation may be the most cost-effective way of solving the problem. Although there is no extra credit for acquisition and relocation of properties in areas of special flooding, the credit offered in Activity 520 is substantial.

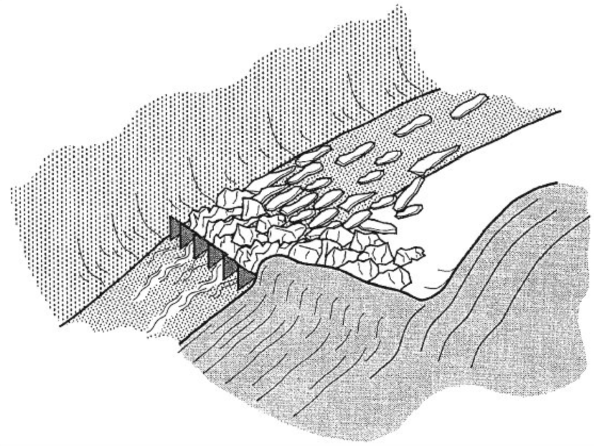
Credit is only provided for buildings within the regulatory floodplain (aRF) that is managed by the community, so the mapping of special hazard areas in Activity 410SH may be important for this credit.

Acquisition and relocation of these properties may also significantly reduce the costs of maintaining and repairing infrastructure in these areas.

530 Flood Protection

There are various structural measures that may be effective in mitigating ice jam hazards. These measures differ according to the type of ice and the type of ice jam hazard expected. Due to the nature and/or the expense of structural measure that are effective in reducing ice jam hazards, it may be necessary to develop multi-jurisdictional or even multi-state projects. For more information, see the U.S. Army Corps of Engineers' *Ice Engineering* manual (U.S. Army Corps of Engineers, 2002), which can be found on the website at http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-1612/toc.htm.

In areas adjacent to closed basin lakes, structural measures should be considered a last-ditch effort to protect buildings and infrastructure from rising lake levels. Because lake levels tend to remain high for long periods of time, the water table will rise on the landward side of levees and flood walls. Structural measures may be effective if the lake level is approaching its outflow point. Structural measures (channelization) may be effective for lowering the maximum potential level of a lake, and this would be eligible for CRS credit for structural protection of buildings.



An ice control structure and ice storage area (from U.S. Army Corps of Engineers, 2002, p. 12-11).

There are some structural measures that may be effective in mitigating mudflow and landslide hazards. These measures differ according to the type of hazard and its location relative to the community. Due to the nature and/or the expense of structural measure that are effective in mudflow or landslide hazards, it may be necessary to develop multi-jurisdictional or even multi-state projects.

If the rate of land subsidence is low, levees may provide protection, but they may be damaged as a result of differential land subsidence, making them subject to failure.

A variety of structural approaches to mitigate uncertain flow path hazards are in use to some extent in many communities. Sediment dams are expensive and require removal of the sediment by mechanical means after every major flood. Grade control structures and bank protection in reaches where channels tend to migrate are expensive and subject to failure. In general, the very nature of uncertain flow path flooding causes structural measures to be expensive and difficult to design.

540 Drainage System Maintenance

Drainage system maintenance may be extremely important in areas with special hazards. The nature of some of these hazards indicates that there will be changes during every flooding episode and, in some cases, the hazard and the hazard area will change from time to time. The only way to even begin to deal with these problems is to inspect all channels and critical areas annually and after every significant event. These inspections will ensure that the system is not damaged and that debris is removed so that the system is fully operational. There is also credit in this activity for capital improvement plans that fund projects to reduce maintenance problems.

600 Flood Preparedness Activities

Areas subject to special hazards are inherently more dangerous than most riverine floodplains because of the high velocities and the sediment and debris in the water. Although there is no specific credit in CRS Activities 610, 620, and 630, they deserve special attention by communities that face these hazards.

610 Flood Warning

NOTE: A separate publication, ***CRS Credit for Flood Warning Programs****, includes examples of community programs and application documentation. Communities are encouraged to read this document before applying for flood warning credit. It will improve the quality of the application and reduce the need for additional documentation later. For a free copy, see Appendix E of the* ***Coordinator's Manual****.*

In communities with a history of ice jam flood damage, the community's emergency plan should include warning dissemination and evacuation planning for the area subject to ice jam damage. In most cases, ice jam flooding can be predicted, and advance warning can allow property owners to move building contents, vehicles, and animals away from areas that are to be flooded. If the area is only subject to higher flood levels as a result of an ice jam, some temporary floodproofing measures may also be effective where there is a warning.

Because closed basin lake flooding generally occurs over a long period of time (weeks, months, or years), flood warning is generally not needed as a mitigation tool.

Flood hazards due to land subsidence, on the other hand, may be mitigated by flood warning. Even though the hazard generally develops slowly, the increased flood hazard that results may include rapid-onset flooding.

In some communities, the U.S. Geological Survey and/or state agencies are actively working on systems to monitor potential mudflows in real time. Any community that would benefit from such a system should make sure that this system will serve as a warning mechamism by informing the public of the system, integrating the monitoring system into its emergency response plan, and taking the other actions needed to use the real-time information effectively to save lives and reduce damage.

In many areas in the arid West, large tracts of land are owned by state and federal agencies and are virtually unpopulated. Flood warning may be needed for populated areas downstream. Due to the steep slopes in many of these areas, floods develop quickly in response to rainfall. They travel downstream rapidly and the flood levels rise quickly when the flows arrive. The watershed response time for a watershed of several thousand square miles may be less than 24 hours.

Traditional flood warning for these areas usually does not exist. There is little population in the watershed, so there are few rain gages. The streams are usually dry, so there are few stream gages.

A number of large communities, counties and even states have developed “ALERT” (automated local evaluation in real time) warning systems in the watersheds that affect them. See Activity 610 in the *Coordinator’s Manual* for a discussion of these flood warning systems.

620 Levee Safety

Levees in arid regions may require more frequent and more extensive maintenance due to erosion, sedimentation, and channel migration. Levees may also require special construction standards and/or maintenance if they are in areas subject to subsidence, or if they are in long-term contact with water adjacent to a closed basin lake.

630 Dam Safety

Dams in arid regions are no more or less unsafe than other dams. However, they serve as sediment traps, and their effective lifetime is limited unless the sediment is removed. In some areas, dams have been built for the specific purpose of removing sediment from streams upstream from developed areas so that the channels below remain more stable. The reservoir areas behind these dams must be cleaned frequently or they will become ineffective.

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National Flood Insurance Program
Community Rating System

Special Hazards Supplement to the *CRS Coordinator's Manual*

ACTIVITY WORKSHEETS

2006

FEMA

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Expires: June 30, 2007

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AW-TS	Tsunami Hazards
AW-UF	Uncertain Flow Path Hazards

INSTRUCTIONS

The following activity worksheets are to facilitate calculations of Community Rating System (CRS) credit points. They are not used for a community's initial application to the CRS. INITIAL APPLICATIONS FOR THE CRS ARE SUBMITTED USING THE WORKSHEET PAGES IN THE *CRS APPLICATION*.

These activity worksheets are for internal use by the community, for submittal of modifications, and for use by the ISO/CRS Specialist during verification and cycle verification of a community's program.

These worksheets are designed to be used in conjunction with the *Special Hazards Supplement to the CRS Coordinator's Manual*. Each section of the worksheets corresponds to a section in that supplement. If a section is missing from the worksheets, it is because the *Special Hazards Supplement* shows that no data or calculations are required for that section.

It is recommended that these worksheets be photocopied before they are used.

When used for submitting a modification, the Credit Points, Credit Calculation, and Credit Documentation parts of the worksheets should be completed for each activity for which credit is requested. Fill in the blanks with the value for each variable.

Each worksheet has a Credit Documentation section. Check the blanks to denote that all of the required documentation is available. In some cases, the documentation must be provided with the modification. In others, checking the appropriate spaces confirms that you will provide the documentation when needed. Please consult the *Special Hazards Supplement to the CRS Coordinator's Manual* if you have questions about which documentation is to be provided with the request for a modification.

ATTACH THE REQUIRED DOCUMENTATION FOR AN ACTIVITY TO THE WORKSHEET FOR THAT ACTIVITY. If the documentation is ordinance language, attach only the necessary page(s) from the ordinance.

MARK THE MARGINS OF THE DOCUMENTATION WITH THE ACRONYM for the element so the ISO/CRS Specialist can identify the basis for the credit.

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Community : ___________________________

410SH Additional Flood Data for Special Hazard Areas

411SH Credit Points

a. Prerequisites

___ 1. The community receives at least 20 points for its special hazard area regulations.

___ 2. The community has a regulatory map showing the special hazard areas or it requires developers to provide the needed map information.

b. Mapping Credit:

1. Ice jams: no credit because mapping ice jams is an NFIP mapping requirement
2. Closed basin lakes: no credit because mapping closed basin lakes is an NFIP mapping requirement
3. Mudflow hazards: MMF = _____
4. Areas subject to land subsidence: MSU = _____
5. Uncertain flow paths:
   (a) Alluvial fans: no credit because mapping alluvial fans is an NFIP mapping requirement.
   (b) Moveable bed streams: MUF = _____

412SH Credit Calculation

cAFDSH = MMF + MSU + MUF   cAFDSH = _____

Note that the total of cAFDSH + cSHOS + cSHR cannot exceed 200 points.

413SH Credit Documentation

____ a. A map that shows the areas subject to the special hazards and the other floodplains (including the SFHA) in the community.

____ b. A description of the method used for the mapping that shows that it reasonably delineates areas subject to the special hazards and documentation that the method is acceptable to the FEMA Region.

____ c. Credit for 410SH is only provided if the mapping is used for land use regulation to prevent damage from the special hazard. The documentation required for Activity 430SH will suffice for this prerequisite.

Comments: ____

____

____

____

____

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Community : ____________________________

420SH Open Space Preservation in Special Hazard Areas

421SH Credit Points

a. Prerequisites

_____1. The area is eligible for credit for open space preservation under Activity 420

_____2. The area is mapped as subject to the special hazard as credited under Activity 410SH.

422SH Impact Adjustment

a. Option 1: rSHOS = 1.0

b. Option 2: rSHOS = 0.2

c. Option 3: rSHOS = $\frac{\text{aSHOS\_\_\_\_\_}}{\text{aSH\_\_\_\_\_}}$ = ________

423SH Credit Calculation

cSHOS = 50 x rSHOS _______ cSHOS = _____

Enter this value in line 423.d on AW-420-1

Note that the total of cAFDSH + cSHOS + cSHR cannot exceed 200 points.

424SH Credit Documentation

____ a. Documentation showing the community qualifies for credit under 410SH.

____ b. Documentation showing the area where open space credit is requested is in the special hazard area and meets the open space requirements of Activity 420.

Comments: ____

____

____

____

____

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Community : ____________________________

430SH Higher Regulatory Standards For Special Hazards

431SH Credit Points

a. Prerequisites

_____ 1. The area regulated is mapped as subject to the special hazard as credited under Activity 410SH.

_____ 2. The community has adopted and is enforcing the higher regulatory standards.

b. Credit points

1. Ice jam regulations: IJR = _____
2. Closed basin lake regulations: CBR = _____
3. Mudflow hazard regulations: MFR = _____
4. Land subsidence regulations: SUR = _____
5. Uncertain flow path regulations: UFR = _____

432SH Impact Adjustment

a. Option 1: If the community does not receive credit for SHOS in 420SH, then rSHOS = 0.

rIJR = 1.0 – rSHOS = _____

rCBR = 1.0 – rSHOS = _____

rMFR = 1.0 – rSHOS = _____

rSUR = 1.0 – rSHOS = _____

rUFR = 1.0 – rSHOS = _____

b. Option 2: rSHOS = 0.25

c. Option 3:

$$rIJR = \frac{aIJR\_\_\_\_\_}{aIJ\_\_\_\_\_} = \_\_\_\_\_\_\_\_\_$$

$$rCBR = \frac{aCBR\_\_\_\_\_}{aCB\_\_\_\_\_} = \_\_\_\_\_\_\_\_\_$$

$$rMFR = \frac{aMFR\_\_\_\_\_}{aMF\_\_\_\_\_} = \_\_\_\_\_\_\_\_\_$$

$$rSUR = \frac{aSUR\_\_\_\_\_}{aSU\_\_\_\_\_} = \_\_\_\_\_\_\_\_\_$$

$$rUFR = \frac{aUFR\_\_\_\_\_}{aUF\_\_\_\_\_} = \_\_\_\_\_\_\_\_\_$$

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Community : ___________________________

433SH Credit Calculation

a. cIJR = IJR x rIJR _______	cIJR = _____
b. cCBR = CBR x rCBR _______	cCBR = _____
c. cMFR = MFR x rMFR _______	cMFR = _____
d. cSUR = SUR x rSUR _______	cSUR = _____
e. cUFR = UFR x rUFR _______	cUFR = _____
f. cLZSH (from AW-430LZSH)	cLZSH = _____
Add the lines above	cSHR = _____

Enter this value in line 433.k on AW-430-2

NOTE: *the total of cAFDSH + cSHOS + cSHR cannot exceed 200 points.*

434SH Credit Documentation

____ a. The state or local law or ordinance language that adopts the regulatory standard.

____ b. An explanation of the procedures followed for enforcement.

Comments: ____

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OMB No. 1660-0022
Expires: June 30, 2007

Public reporting burden for this information collection is estimated at 35 hours for the application and certification process. Burden means the time, effort, and financial resources expended by persons to generate, maintain, retain, disclose, or to provide information to us. You may send comments regarding the burden estimate or any aspect of the collection, including suggestions for reducing the burden to: Information Collections Management, U.S. Department of Homeland Security, Emergency Preparedness and Response Directorate, Federal Emergency Management Agency, 500 C St., S.W., Washington, D.C. 20472, Paperwork Reduction Project (OMB Control Number 1660-0022). You are not required to respond to this collection of information unless a valid OMB control number is displayed in the upper right corner of this form. Note: do not send your completed questionnaire to this address.

Activity Worksheet No.	Title
AW-210	CRS Application Cover Page
AW-214	Recertification Worksheet
AW-230	Modification/Cycle Cover Page
AW-310	Elevation Certificates
AW-320	Map Information Service
AW-330	Outreach Projects
AW-340	Hazard Disclosure
AW-350	Flood Protection Information
AW-360	Flood Protection Assistance
AW-410	Additional Flood Data
AW-420	Open Space Preservation
AW-430	Higher Regulatory Standards
AW-430LD	Land Development Criteria
AW-440	Flood Data Maintenance
AW-450	Stormwater Management
AW-501	Repetitive Loss List
AW-502	Repetitive Loss Requirements
AW-510	Floodplain Management Planning
AW-520	Acquisition and Relocation
AW-530	Flood Protection
AW-540	Drainage System Maintenance
AW-610	Flood Warning Program
AW-620	Levee Safety
AW-630	Dam Safety
AW-710	Community Growth Adjustment
AW-720	Community Credit Calculations
AW-720m	Community Credit Calculations (Modification)
AW-CB	Closed Basin Lake Hazards
AW-CE	Coastal Erosion Hazards
AW-DB	Dunes and Beaches
AW-IJ	Ice Jam Hazards
AW-MF	Mudflow Hazards
AW-SU	Land Subsidence Hazards
AW-TS	Tsunami Hazards
AW-UF	Uncertain Flow Path Hazards

OMB No.1660-0022
Expires June 30, 2007

Community : ____________________________

430LZSH Low Density Zoning in Special Hazard Areas

432LZSH Impact Adjustment

a. Option 1: Enter rSHOS from AW-420SH-1. If the community does not receive credit for SHOS in 420SH, then rSHOS = 0.

rLZSH__ = 1.0 - rSHOS ______ = ______

b. Option 2: rLZSH__ = 0.2

c. Option 3:

1. rLZSH___ = $\frac{\text{aLZSH \_\_\_\_\_\_\_}}{\text{aSH}}$ = ______

2. rLZSH___ = $\frac{\text{aLZSH \_\_\_\_\_\_\_}}{\text{aSH}}$ = ______

3. rLZSH___ = $\frac{\text{aLZSH \_\_\_\_\_\_\_}}{\text{aSH}}$ = ______

433LZSH Credit Calculation

cLZSH____ = LZSH____ ______ x rLZSH____ _______ cLZSH___ = _______

cLZSH____ = LZSH____ ______ x rLZSH____ _______ cLZSH___ = _______

cLZSH____ = LZSH____ ______ x rLZSH____ _______ cLZSH___ = _______

Add the lines above cLZSH = ______

Enter this value in line 433SH.f on AW-430SH-2

434LZSH Credit Documentation

____ a. The ordinance language that adopts the low density zoning standard.

____ b. The Impact Adjustment Map

____ c. An explanation of how the regulations are enforced.

____ d. Examples of developments constructed in accordance with the zoning density.

Comments: ____

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OMB No. 1660-0022
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