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"Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas, Chapter 4 , Siting"
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4 Siting

Siting residential buildings to minimize their vulnerability to coastal hazards should be one of the most important aspects of the development (or redevelopment) process. Informed decisions regarding siting, design, and construction begin with a complete and detailed understanding of the advantages and disadvantages of potential sites for coastal construction. Gaining this knowledge ***prior*** to the purchase of coastal property and the initiation of design is important to ensure that coastal residential buildings are properly sited to minimize risk.

CROSS REFERENCE

For resources that augment the guidance and other information in this Manual, see the Residential Coastal Construction Web site (http://www.fema.gov/rebuild/mat/fema55.shtm).

Experience has shown that not all coastal lands are suitable for development, or at least not the type and intensity of development that has occurred on some coastal lands in the past. Prudent siting has often been overlooked or ignored in the past; properties have been developed and buildings have been constructed close to the shoreline, near bluff edges, and atop steep coastal ridges. Unfortunately, many similar siting and development decisions are still made every day based on site conditions at the time of purchase or on an incomplete or inaccurate assessment of existing and future conditions. Too often, these decisions leave property owners and local governments struggling with a number of ***avoidable*** problems:

- Damage to, or loss of, buildings
- Damage to attendant infrastructure
- Buildings located on public beaches as shorelines erode
- Vulnerable buildings and infrastructure that require emergency or permanent protection measures and/or relocation

NOTE

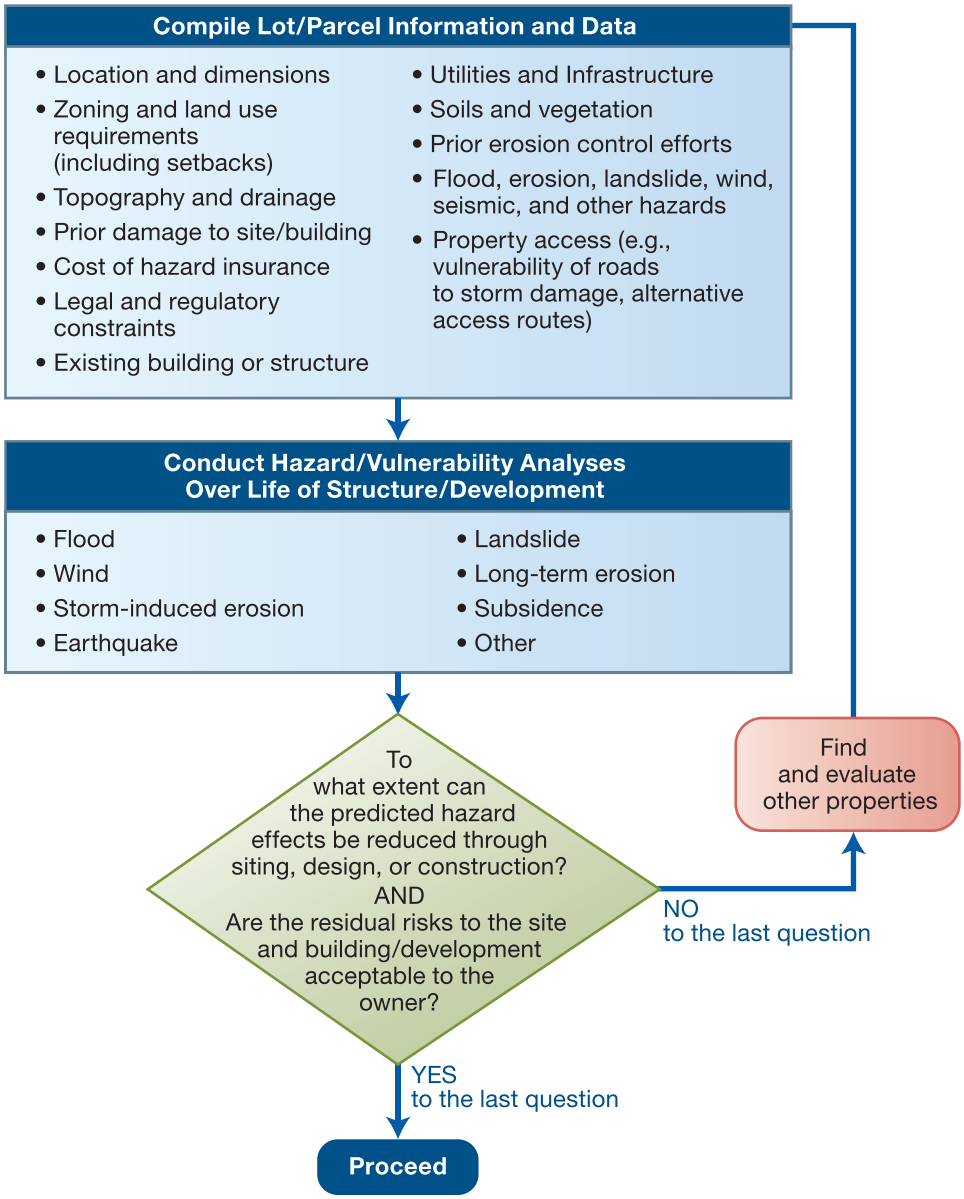
One of the principal objectives of this Manual is to improve site selection for coastal buildings.

- Emergency evacuation
- Injuries and loss of life

A thorough evaluation of coastal property for development purposes involves four steps (see Figure 4-1):

1. Compile lot/parcel information for one or more candidate properties; for each property, follow steps 2 through 4.
2. Identify hazards and assess risk.
3. Determine whether the risk can be reduced through siting, design, or construction and whether the residual risks to the site and the building are acceptable.

Figure 4-1. Evaluation of coastal property



4. Either proceed with the purchase or development of a property, or reject the candidate properties, and find and evaluate other properties.

A building or development site need not be vacant or undeveloped land. Indeed, much of the construction occurring in coastal communities today involves replacement of existing buildings, infill development between adjacent buildings, or redevelopment of previously developed property (refer to Figure 4-2). This chapter addresses property evaluation broadly and applies to the following types of development:

- **Development of raw land.** Development on large, vacant parcels, usually without existing on-site access roads and utilities.
- **Development on previously subdivided lots.** Development on previously subdivided or platted lots or small parcels, usually with roads and utilities in place and surrounded by or adjacent to residential structures. Lots may or may not be vacant. This category includes infill development and redevelopment.

WARNING

Many coastal property buyers fail to investigate potential risk to their land and buildings. Designers should work with owners to identify and mitigate those risks.

WARNING

Some severe coastal hazards cannot be mitigated through design and construction. A design and construction "success" can be rendered a failure by poor siting.

WARNING

The NFIP does not insure buildings that are entirely over water or principally below ground.

Today, there are relatively few places along the shoreline where there is insufficient information to make rational, informed siting decisions. Following the lessons and procedures described in this Volume of the Manual will help designers, purchasers, owners, developers, and community officials identify those locations where coastal residential development and buildings can be sited so that the risks are minimized. An otherwise successful design can be negated by failure to site a building properly. The North Carolina house shown in Figure 4-3 illustrates this type of failure; while the house appears to be a structural success, long-term erosion has left it standing permanently in the water and uninhabitable. In contrast, a siting

Figure 4-2. Redevelopment on a previously developed lot as part of the rebuilding process after Hurricane Katrina (Lakeview, LA)

Figure 4-3.
Long-term erosion left this well-built Kitty Hawk, NC, house standing in the ocean (Hurricane Dennis, 1999)
SOURCE: D. GATLEY, FEMA

Figure 4-4.
Although sited away from the shore, winds from Hurricane Floyd (1999) tore off the large overhanging roof of this house in Wrightstville Beach, NC

success can be overshadowed by poor design, construction, or maintenance. The North Carolina house shown in Figure 4-4 was set back from the shoreline and safe from long-term erosion, but, it could not resist winds from Hurricane Floyd in 1999.

4.1 Identifying Suitable Property for Coastal Residential Structures

The first step in the coastal development or construction process involves the purchase of a vacant or previously developed lot or parcel. This step, in many ways, constrains subsequent siting, design, and construction decisions and determines the long-term vulnerability of coastal residential buildings. ***Prospective property buyers who fail to fully investigate properties before acquiring them may subsequently be faced with a variety of problems that are difficult, costly, or essentially impossible to solve.***

Although this Manual does not address the initial identification of candidate properties in detail, buyers and design professionals who assist them with property evaluations should keep the following in mind as they narrow their search for a suitable building/development site:

- The geographic region or area a buyer is interested in determines the ***hazards*** to which the property is exposed.
- An ***existing erosion control structure*** on or near a lot or parcel is an indication of prior erosion, but the structure cannot be assumed to be adequate to protect a building or development in the future.
- The ***vulnerability of a coastal building generally increases with time,*** as a result of one or more of the following: gradual weakening or deterioration of the building itself; sea level or lake level rise; or erosion-induced shoreline recession, which affects the majority of coastal areas in the United States.
- ***Future development activities*** and patterns on adjacent and nearby properties may affect the vulnerability of buildings or development on any given property.
- Any given lot or parcel ***may not be suitable for the purchaser's intended use*** of the property.
- Land use, zoning, setbacks, public health regulations, floodplain management, building code, and related requirements generally determine development densities, building size and location limitations, minimum design and construction practices, and allowable responses to erosion hazards; however, ***compliance with these requirements does not ensure the future safety*** of the building or development.

WARNING

Before any purchase, each buyer should, in consultation with experts and local officials, determine the acceptable level of residual risk and decide how to manage the actual risks expected over the life of the building or development. Note that ***risk assessment, risk tolerance, and risk reduction issues are not simple***—property acquisition and development decisions should be based on a wide range of information.

CROSS REFERENCE

Refer to Chapter 3 for discussion of coastal hazards, including flooding, erosion, wind, earthquake, and other environmental considerations.

Refer to Chapter 6 for descriptions of risk assessment, risk tolerance, and residual risk.

- Development practices that perpetuate or duplicate historical siting, design, or construction practices do not ensure the future safety of new buildings and/or development. ***Many historical practices are inadequate*** by today's standards; further, changing shoreline conditions may render those practices obsolete.
- ***Property selection***—along with subsequent siting, design, construction, and maintenance decisions—***determines the vulnerability*** of and risk to any building or improvements.

Narrowing the search for coastal property suitable for development or redevelopment requires careful consideration of a variety of property and area characteristics, including the nature and success of previous erosion control efforts (e.g., groins and revetments). Note that some communities and States restrict or prohibit the construction or reconstruction of revetment, seawall, and groin structures such as those shown in Figure 4-5.

A number of States require that residential real estate transactions be accompanied by a disclosure of information pertaining to flood hazards and other hazards (if the seller or agent knows of such hazards). However, the requirements concerning the form and timing of disclosures differ. Therefore, the type and amount of information that must be disclosed varies widely. Taken collectively, the disclosure requirements

Figure 4-5.
Groins were installed in an attempt to stop erosion (note narrower beaches downdrift of groins, as shown also in Figure 2-12)

SOURCE: BONNIE M. BENDELL, NORTH CAROLINA DIVISION OF COASTAL MANAGEMENT, USED WITH PERMISSION

(in force and as proposed) provide a good indication of the types of information that prospective property buyers and designers should seek, whether or not their State requires such disclosure. Builders should contact a real estate agent or real estate attorney for a list of real estate natural hazard disclosure laws in their State.

4.2 Compiling Information on Coastal Property

After candidate properties are identified, the next step is to compile a wide range of information for each property. This is no trivial matter; this step may require considerable time and effort. Table 4-1 is a list of general information that should be compiled. Information listed in Table 4-1 is usually available from local, regional, State, or Federal governments, from universities, or from knowledgeable professionals; however, the availability and quality of the information will vary by State and community.

Table 4-1. General Information Needed to Evaluate Coastal Property

Property Location	
• Township/county/jurisdiction • Street address • Parcel designation/tax map ID • Subdivision information	• Special zoning or land use districts • Other hazard area designation • Natural resource protection area designation
Property Dimensions	
• Total acreage • Water-ward property boundary (platted or fixed line; moving line [e.g., mean high water line, mean low water line, or other datum, elevation, feature]) • Property shape • Property elevations and topography • Location relative to adjacent properties • Configuration of adjacent properties • Shoreline frontage (i.e., dimension parallel to shoreline) • Property depth (i.e., dimension perpendicular to shoreline) • Acreage landward/outside of natural, physical, or regulatory construction or development limits (i.e., usable acreage)	
Planning and Regulatory Information	
• Hazard Mitigation Plan • Land use designation at property and adjacent properties • Zoning classification and resulting restrictions on use • Building code and local amendments • Flood hazard area: elevation and construction requirements • Erosion hazard area: construction setbacks and regulations • Natural resource protection area: siting, construction, or use restrictions • Easements and rights-of-way on property (including beach access locations for nearby properties or the general public) • Local and State siting and construction regulations • Regulatory front, back, and side setbacks • Local and State permitting procedures and requirements • Local and State regulations regarding use, construction, and repair of erosion control measures • Riparian rights • Local and State restrictions on cumulative repairs or improvements • Conditions or other requirements attached to building or zoning permits • Subdivision plat covenants and other restrictions imposed by developers and homeowner's associations • Hazard disclosure requirements for property transfer, including geologic hazard reports	
Physical and Natural Characteristics	
• Soils, geology, and vegetation – site and regional • Topography of nearshore (including nearshore slope), beach, dune, bluff, uplands • Site drainage – surface water and groundwater • Littoral sediment supply and sediment budget • Storm, erosion, and hazard history of property • Erodibility of the nearshore bottom • Erosion control structure on site – type, age, condition, and history • Proximity to inlets and navigation structures • Previous or planned community/regional beach/dune restoration projects • Relative sea level/water level changes – land subsidence or uplift	
Infrastructure and Supporting Development	
• Access road(s) • Emergency evacuation route(s) • Electric, gas, water, telephone, and other utilities – onsite or offsite lines and hookups • Sewer or septic requirements/limitations • Limitations imposed by utility/infrastructure locations on property use	

Table 4-1. General Information Needed to Evaluate Coastal Property (concluded)

Financial Considerations
• Intended use – owner-occupied or rental property • Real estate taxes • Development impact fees • Permit fees • Hazard insurance – availability, premiums, deductibles, and exclusions • Property management fees • Special assessments for community/association projects (e.g., private roads and facilities, dune preservation) • Maintenance and repair of private erosion control structures • Increased building maintenance and repairs in areas subject to high winds, wind-driven rain, and/or salt spray • Building damage costs (insured and uninsured) from previous storms

Communities participating in the NFIP should have a FIRM and FIS on file for the community (see Section 3.6.3). The FIS includes detailed flood hazard data for parts of the community and usually includes a narrative of the flood history of a community.

The best source of current hazard information is at the local level due to the local officials' knowledge of local hazards, policies, codes, and regulations. Many States and communities produce brochures or publications to help property owners and prospective buyers evaluate coastal property. The publications listed below are examples of the types of information available.

- *Natural Hazard Considerations for Purchasing Coastal Real Estate in Hawai'i: A Practical Guide of Common Questions and Answers* (University of Hawaii Sea Grant College Program 2006), answers common questions that are considered when purchasing developed and undeveloped coastal real estate. It includes a strong focus on long-term erosion, which is the most common coastal hazard in Hawaii.
- *Living on the Coast: Protecting Investments in Shore Property on the Great Lakes* (University of Wisconsin Sea Grant Program 2004) contains a description of natural processes that affect the Great Lakes coast from glacial melt and lake level rise to local erosion. It also includes information on risk management and protecting coastal properties that is relevant to all coastal areas. The FEMA Residential Coastal Construction Web page includes a list of Web resources relevant to Great Lakes hazards adapted from the University of Wisconsin Sea Grant Program.

NOTE

Owners and prospective buyers of coastal property should contact their community or State officials for publications and data that will help them evaluate the property.

- *A Manual for Researching Historical Coastal Erosion* (Fulton 1981) describes in detail how to use historical weather data, local government records, and historical maps and photographs to understand and quantify shoreline, sea bluff, and cliff retreat. Two communities in San Diego County, CA are used as case studies to illustrate the research methods presented.
- *Questions and Answers on Purchasing Coastal Real Estate in South Carolina* (South Carolina Sea Grant Extension Program 2001) provides prospective property owners with basic information on a variety of topics, including shoreline erosion, erosion control, high winds, and hazard insurance (including earthquakes).

In the absence of current hazard information, historical records can be used to preduct future hazard conditions, impacts, and frequencies. However, natural and manmade changes at a site may render simple extrapolation of historical patterns inaccurate.

4.3 Evaluating Hazards and Potential Vulnerability

Evaluating hazards and the potential vulnerability of a building is perhaps most crucial when evaluating the suitability of coastal lands for development or redevelopment. Basing hazard and vulnerability analyses solely on building code requirements, the demarcation of hazard zones or construction setback lines, and the location and design of nearby buildings is inadequate. A recommended procedure for performing such an evaluation is outlined in the next section.

4.3.1 Define Coastal Hazards Affecting the Property

Defining the coastal hazards affecting a property under consideration for development requires close examination of both historical and current hazard information. This Manual recommends the following steps:

Step 1: Use all available information to characterize the type, severity, and frequency of hazards (e.g., flood, storm-induced and long-term erosion, accretion or burial, wind, seismic, tsunami, landslide, wildfire, and other natural hazards) that have affected or could affect the property.

Step 2: Examine the record for long-term trends (> 50–100 years), short-term trends (< 10–20 years), and periodic or cyclic variations (both spatial and temporal) in hazard events. Determine whether particularly severe storms are included in the short-term or long-term records and what effects those storms had on the overall trends. If cyclic variations are observed, determine the periods and magnitudes of the variations.

Step 3: Determine whether or not extrapolation of historical trends and hazard occurrences is reasonable. Examine the record for significant changes to the coastal system or inland and upland areas that will reduce, intensify, or modify the type, severity, and frequency of hazard occurrence at the property. The following are examples of events or processes that preclude simple extrapolation of historical trends:

- Loss of a protective dune or bluff feature that had been there for a long time may lead to increased incidence and severity of flood or erosion damage.
- Loss of protective natural habitats, such as marshes, swamps, coral reefs, and shoreline vegetation, can increase vulnerability to erosion and flooding.

NOTE

This Manual is intended primarily for design professionals, coastal specialists, and others with the expertise to evaluate coastal hazards and the vulnerability of sites and buildings to those hazards, and to design buildings in coastal areas. Readers not familiar with hazard and vulnerability evaluations are encouraged to seek the services of qualified professionals.

CROSS REFERENCE

Chapter 3 presents additional information about natural hazards in coastal areas and the effects of those hazards.

Chapter 6 provides information about recurrence intervals.

- Significant increases in sea, bay, or lake levels generally increase vulnerability to flooding and coastal storm events.
- Erosion or storms may create weak points along the shoreline that are predisposed to future breaching, inlet formation, and accelerated erosion, or may expose geologic formations that are more resistant to future erosion.
- Recent or historical modifications to an inlet (e.g., construction or modification of jetties, creation or deepening of a dredged channel) may alter the supply of littoral sediments and modify historic shoreline change trends.
- Formation or closure of an inlet during a storm alters local tide, wave, current, and sediment transport patterns and may expose previously sheltered areas to damaging waves (see Figures 3-39 and 3-41 in Chapter 3).
- Widespread construction of erosion control structures may reduce the input of sediments to the littoral system and cause or increase local erosion.
- Recent seismic events may have caused uplift, settlement, submergence, or fracturing of a region, altering its hazard vulnerability to flood and other hazards.
- Changes in surface water flows, drainage patterns, or groundwater movements, and reduction in vegetative cover may increase an area's susceptibility to landslides.
- Topographic changes resulting from the retreat of a sea cliff or coastal bluff may increase wind speeds at a site.
- Exposure changes, such as the removal of trees to create future development, can increase wind pressures on existing buildings at a site.

Step 4: Forecast the type, severity, and frequency of future hazard events likely to affect the property over a suitably long period of time, say over at least 50–70 years. This forecast should be based on either: (1) extrapolation of observed historical trends, modified to take into account those factors that will cause deviations from historical trends; or (2) detailed statistical and modeling studies calibrated to reflect basic physical and meteorological processes, and local conditions. Extrapolation of trends should be possible for most coastal sites and projects. Detailed statistical and modeling studies may be beyond the scope and capabilities of many coastal development projects.

WARNING

Compliance with minimum siting requirements administered by local and State governments does not guarantee a building will be safe from hazard effects. To reduce risks from coastal hazards to an acceptable level, exceeding minimum siting requirements may be necessary.

4.3.2 Evaluate Hazard Effects on the Property

Once the type, severity, and frequency of future hazard events have been forecast, designers should use past events as an indication of the nature and severity of effects likely to occur during those forecast events. Information about past events at the site of interest and at similar sites should be considered. This historical

information should be combined with knowledge about the site and local conditions to estimate future hazard effects on the site and any improvements.

Designers should consider the effects of low-frequency, rare events (e.g., major storms, extreme water levels, tsunamis, earthquakes), and multiple, successive lesser events (see Figure 4-6). For example, many of the post-storm damage assessments summarized in Chapter 2 show that the cumulative erosion and damage caused by a series of minor coastal storms can be as severe as the effects of a single, major storm.

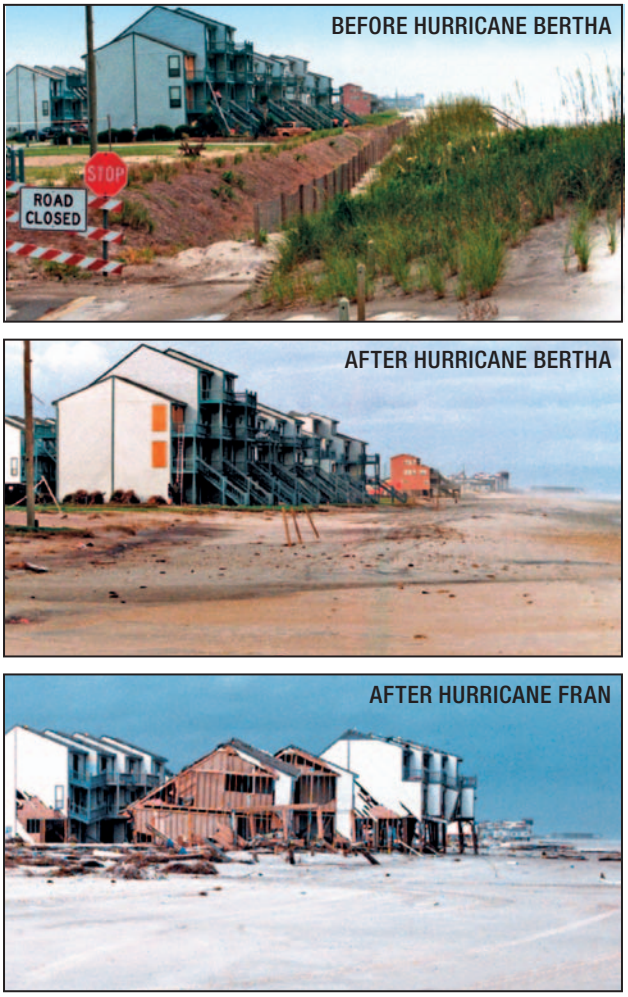


Figure 4-6. Cumulative effects of storms occurring within a short period at one housing development in Jacksonville, NC, July–September 1996
SOURCE: JOHN ALTHOUSE, USED WITH PERMISSION

4.4 General Siting Considerations

It is always best to build in lower risk areas. However, when building in more vulnerable areas, a variety of factors must be considered in selecting a specific site and locating a building on that site. These factors are outlined in Figure 4-1 and include:

- Building code and land use requirements
- Local floodplain management requirements adopted to participate in the NFIP

- Other regulatory requirements
- Presence and location of infrastructure
- Previous development and/or subdivision of property
- Physical and natural characteristics of the property
- Vulnerability of the property to coastal hazards

When siting the foundation of a building in two different flood insurance zones, design and regulatory requirements of the most restrictive zone apply. For example, even though the majority of the foundation of the building illustrated in Figure 4-7 is located in Zone A, Zone V requirements would apply to the entire building.

Regulatory controls do not necessarily prevent imprudent siting of coastal buildings. Figure 4-8 shows flood and debris damage to new construction sited in Zone A that could have been avoided had the site been designated a Coastal A Zone, and had the structure been elevated on an open foundation. Because there are situations where minimum requirements do not address site-specific hazards, prospective buyers should

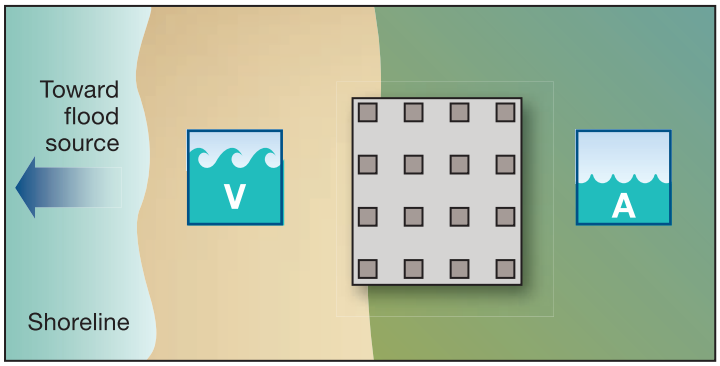


Figure 4-7.
When siting a foundation in two different flood zones, requirements for the most restrictive zone apply to the whole building

Figure 4-8.
Flood and debris damage to new construction in Zone A (Hurricane Opal, 1995)

evaluate a site for its suitability for purchase, development, or redevelopment prior to acquiring the property. However, property owners often undertake detailed studies only after property has been acquired.

Designers should recognize situations in which poor siting is allowed or encouraged, and should work with property owners to minimize risks to coastal buildings. Depending on the scale of the project, this could involve one or more of the following:

- Locating development on the least hazardous portion of the site
- Rejecting the site and finding another
- Transferring development rights to another parcel better able to accommodate development
- Combining lots or parcels
- Reducing the footprint of the proposed building and shifting the footprint away from the hazard
- Shifting the location of the building on the site by modifying or eliminating ancillary structures and development
- Seeking variances to lot line setbacks along the landward and side property lines (in the case of development along a shoreline)
- Moving roads and infrastructure
- Modifying the building design and site development to facilitate future relocation of the building on the same site
- Altering the site to reduce its vulnerability
- Construction of protective structures, if allowed by the community

NOTE

Proper siting and design should take into account both slow-onset hazards (e.g., long-term erosion, multiple minor storms) and rapid-onset hazards (e.g., extreme storm events).

4.5 Raw Land Development Guidelines

Large, undeveloped parcels available for coastal development generally fall into two classes:

- ***Parcels well-suited to development,*** but vacant due to the desires of a former owner, lack of access, or lack of demand for development. Such parcels include those with deep lots, generous setbacks, and avoidance of dune areas—these attributes should afford protection against erosion and flood events for years to come (see Figure 4-9).
- ***Parcels difficult to develop,*** with extensive areas of sensitive or protected resources, with topography or site conditions requiring extensive alteration, or with other special site characteristics that make development expensive relative to nearby parcels. Increasingly, coastal residential structures are planned and constructed as part of mixed-use developments, such as the marina/townhouse development shown in Figure 4-10. Such projects can involve complicated environmental and regulatory issues, as well as more difficult geotechnical conditions and increased exposure to flood hazards.

Figure 4-9.
Example of parcels well-suited to coastal development in Louisiana
SOURCE: USGS

Figure 4-10.
Example of parcels difficult to develop (mixed-use marina/ townhouse development)

Development in both circumstances should satisfy planning and site development guidelines such as those listed in Table 4-2 (adapted from recommended subdivision review procedures for coastal development in California [California Coastal Commission 1994]).

Development of raw land in coastal areas should consider the effects of all hazards known to exist and the effects of those hazards on future property owners. Similarly, such development should consider local, State, or Federal policies, regulations, or plans that will affect the abilities of future property owners to protect, transfer, or redevelop their properties (e.g., those dealing with erosion control, coastal setback lines, post-disaster redevelopment, landslides, and geologic hazards).

Table 4-2. Planning and Site Development Guidelines for Raw Land

Development of Raw Land in Coastal Areas: Summary of Site Planning and Subdivision Guidelines	
DO determine whether the parcel is suitable for subdivision or should remain a single parcel. **DO** ensure that the proposed land use is consistent with local, regional, and State planning and zoning requirements. **DO** ensure that all aspects of the proposed development consider and integrate topographic and natural features into the design and layout. **DO** avoid areas that require extensive grading to ensure stability.	**DON'T** rely on engineering solutions to correct poor planning decisions.
DO study the parcel thoroughly for all possible resource and hazard concerns.	**DON'T** assume that omissions in planning requirements can be corrected during site development.
DO identify and avoid, or set back from, all sensitive resources and prominent land features.	**DON'T** rely on relocation or restoration efforts to replace resources impacted by poor planning decisions
DO consider combining subdivision elements, such as access, utilities, and drainage.	**DON'T** overlook the effects of infrastructure location on the hazard vulnerability of building sites and lots.
DO account for all types of erosion (e.g., long-term erosion, storm-induced erosion, erosion due to inlets) and governing erosion control policies when laying out lots and infrastructure near a shoreline.	**DON'T** overlook the effects to surface and groundwater hydrology from modifications to the parcel.
DO consider existing public access to shoreline and resource areas. **DO** incorporate setbacks from identified high-hazard areas.	**DON'T** plan development on beaches or dunes, on ridge lines or on top of prominent topographical features, on steep slopes, or in or adjacent to streams.
DO use a multi-hazard approach to planning and design.	**DON'T** forget to consider future site and hazard conditions on the parcel.
DO involve a team of experts with local knowledge, and a variety of technical expertise and backgrounds.	**DON'T** assume that engineering and architectural practices can mitigate all hazards.

4.5.1 Road Placement near Shoreline

Based on studies and observations of previous coastal development patterns and resulting damage, there are several subdivision and lot layout practices that should be avoided. The first of these is placing a road close to the shoreline in an area of small lots.

In the case of an eroding shoreline, placing a road close to the shoreline and creating small lots between the road and the shoreline results in buildings, the roadway itself, and utilities being extremely vulnerable to erosion and storm damage, and can lead to future conflicts over shore protection and buildings occupying public beaches. Figure 4-11 is a view along a washed-out, shore-parallel road in Garcon Point, FL, after Hurricane Ivan in 2004. Homes

WARNING

Proper lot layout and siting of building along an eroding shoreline are critical. Failure to provide deep lots and to place roads and infrastructure well away from the shoreline ensures future conflicts over building reconstruction and shore protection.

to the left have lost inland access. Figure 4-12 shows a recommended lot layout that provides sufficient space to comply with State/local setback requirements and avoid damage to dunes. Some communities have land development regulations that help achieve this goal. For example, the Town of Nags Head, NC, modified its subdivision regulations in 1987 to require all new lots to extend from the ocean to the major shore-parallel highway (Morris 1997). Figure 4-13 compares lots permitted in Nags Head prior to 1987 with those required after 1987. The town also has policies and regulations governing the combination of nonconforming lots (Town of Nags Head 1988).

Figure 4-11.
Roads placed near shorelines can wash out, causing access problems for homes such as these located at Garcon Point, FL (Hurricane Ivan, 2004)

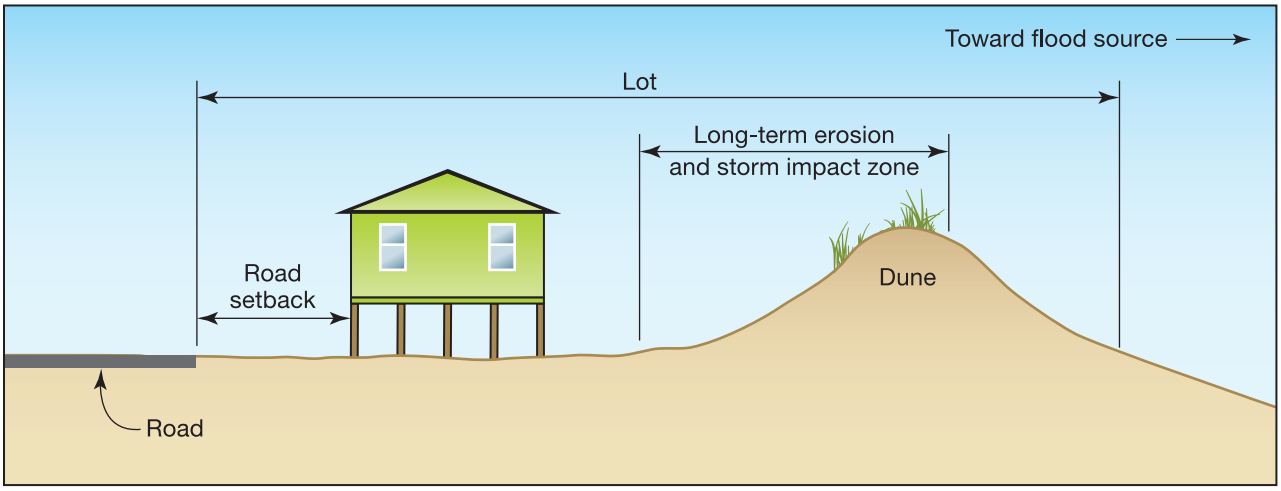


Figure 4-12.
Recommended lot layout for road setback near the shoreline

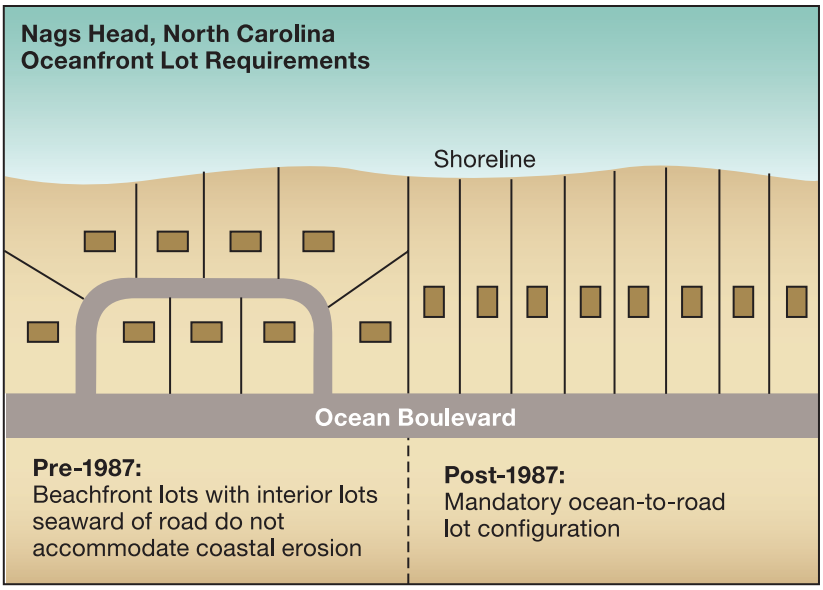


Figure 4-13. Comparison of Nags Head, NC, oceanfront lot layouts permitted before and after 1987
SOURCE: ADAPTED FROM MORRIS 1997

A second problem associated with a shore-parallel road close to the shoreline is storm erosion damage to the road and utilities associated with the road. Some infrastructure damage can be avoided by reconfiguring the seaward lots (so they all have access from shore-perpendicular roads), eliminating the shore-parallel road, and eliminating the shore-parallel utility lines. Figure 4-14 shows shore-parallel roadways and associated utilities that may be vulnerable to storm effects and erosion (upper portion of figure). One alternative to reduce this vulnerability is to create lots and infrastructure without the shore-parallel road, and to install shutoff valves on water and sewer lines (lower portion of figure).

4.5.2 Lot Configurations along Shoreline

Another type of lot layout that is not recommended for vulnerable or eroding coastal shorelines is the "flag" lot or "key" lot illustrated in Figure 4-15. The top layout shown in the figure provides more lots with direct access to the shoreline, but limits the ability of half of the property owners to respond to coastal flood hazards and erosion by constructing or relocating their buildings farther landward. Again, the recommended alternative is to locate the shore-parallel road sufficiently landward to accommodate coastal flooding and future erosion and to create all lots so that their full width extends from the shoreline to the road.

Creation of lots along narrow sand spits and low-lying landforms is not recommended, especially if the shoreline is eroding. Any buildings constructed in such areas will be routinely subjected to coastal storm effects, overwash, and other flood hazards. Figure 4-16 shows construction along a narrow, low-lying area of Dauphin Island, AL, that is routinely subjected to coastal storm effects. Storm surge and waves transported sand across the island during Hurricane Katrina in 2005, essentially shifting the island landward. Most of the houses in this area were destroyed.

Lots should not be created in line with natural or manmade features that concentrate floodwaters (see Figure 4-17). These features can include areas of historic shoreline breaching, roads or paths across dunes, drainage features or canals, and areas of historic landslides or debris flows. Lots located landward of openings between dunes or obstructions may be more vulnerable to flooding and wave effects. Front-row lots waterward of interior drainage features may be vulnerable to concentrated flooding from the inland or bay side. One

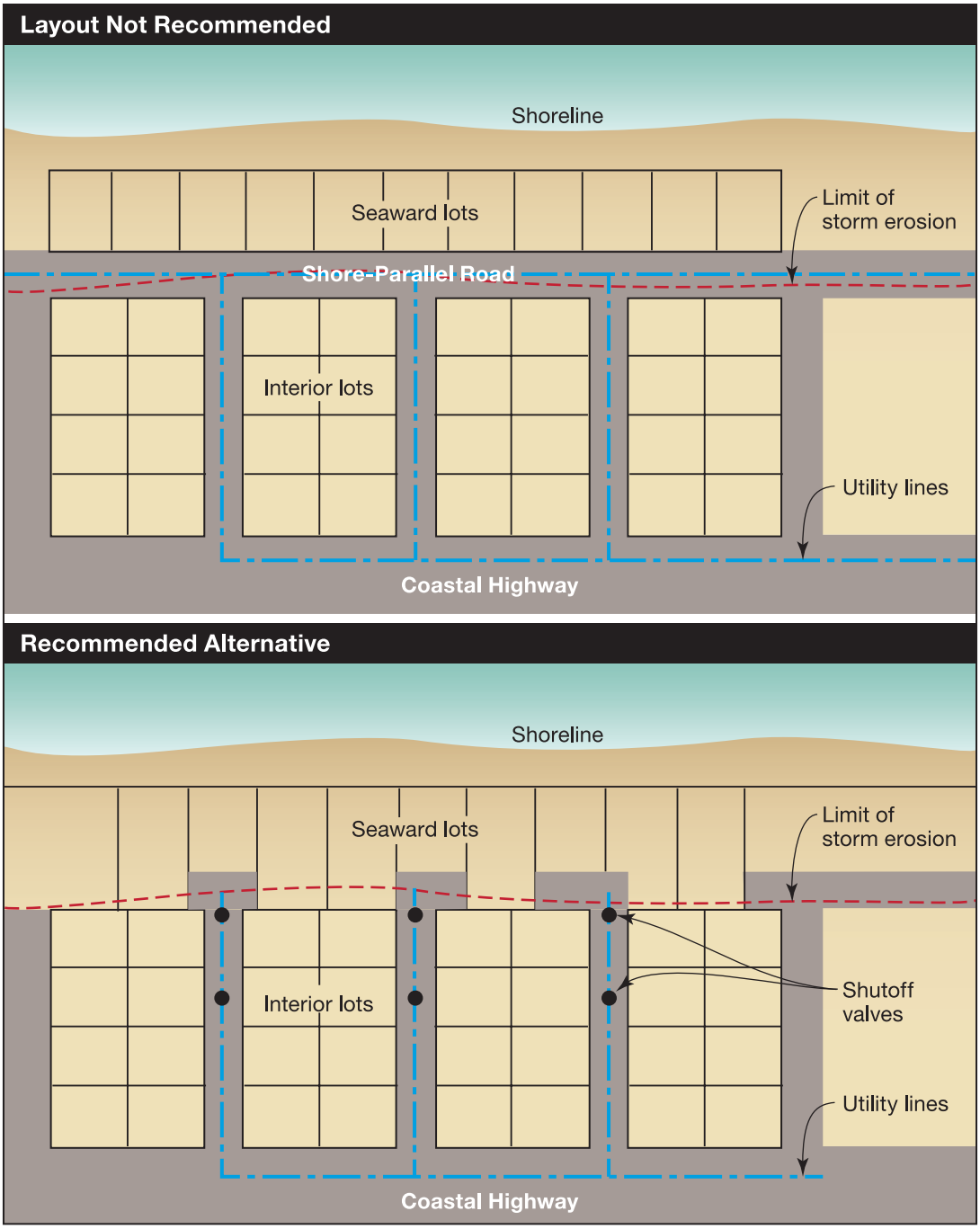


Figure 4-14.
Problematic versus recommended layouts for shore-parallel roadways and associated utilities

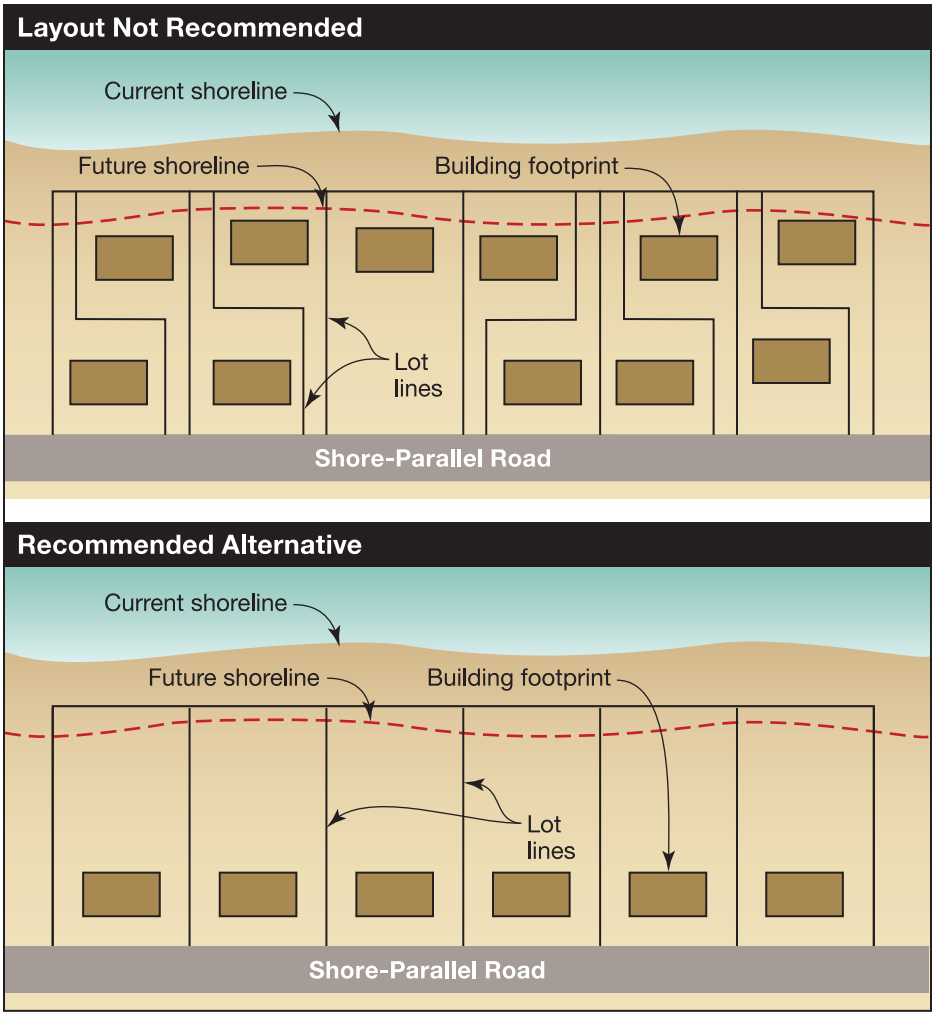


Figure 4-15.
Problematic versus recommended layouts for shoreline lots

Figure 4-16.
Narrow, low-lying areas and barrier islands (such as Dauphin Island, AL, shown in the photograph) are routinely subjected to coastal storm effects (Hurricane Katrina, 2005)
SOURCE: USGS

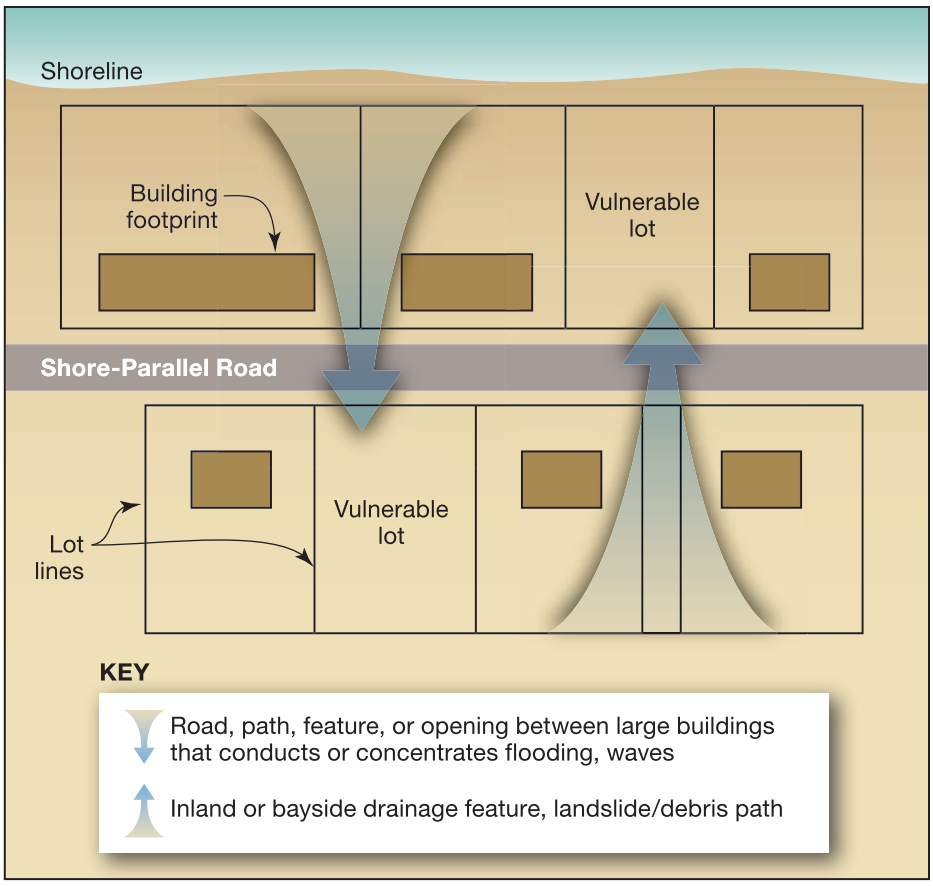


Figure 4-17.
Lots created in line with natural or manmade features can concentrate floodwaters

alternative is to leave these vulnerable areas as open space or to modify them to reduce associated hazards to adjacent lots. Care should also be exercised when lots are created landward of or in gaps between large buildings or objects capable of channeling floodwaters and waves (see Figures 3-20, 3-21, and 3-22).

Configurations should not concentrate small lots along an eroding or otherwise hazardous shoreline. Creating deeper lots, locating building sites farther landward on the lots, or clustering development away from the shoreline is preferable. Figure 4-18 illustrates this progression, from a "conventional" lot layout, to a "modified" lot layout, to a "cluster development" layout with lot line changes. The California Coastal Commission (1994) also developed similar alternatives for a parcel on a ridge top with steep slopes and for a parcel bisected by a coastal lagoon. Another related approach is to occupy a small fraction of the total buildable parcel and to accommodate erosion by moving threatened buildings to other available sites on the parcel. A small Pacific Ocean community in Humbolt County, CA, successfully employed this approach (Tuttle 1987), as shown in Figure 4-19, which shows a community of 76 recreational cabins on a 29-acre parcel, jointly owned by shareholders of a corporation. As buildings are threatened by erosion, they are relocated (at the building owners' expense) to other sites on the parcel, in accordance with a cabin relocation policy adopted by the corporation.

NOTE

Some States and communities have adopted regulations requiring that buildings sited in erosion-prone areas be movable. For example, Michigan has such a requirement.

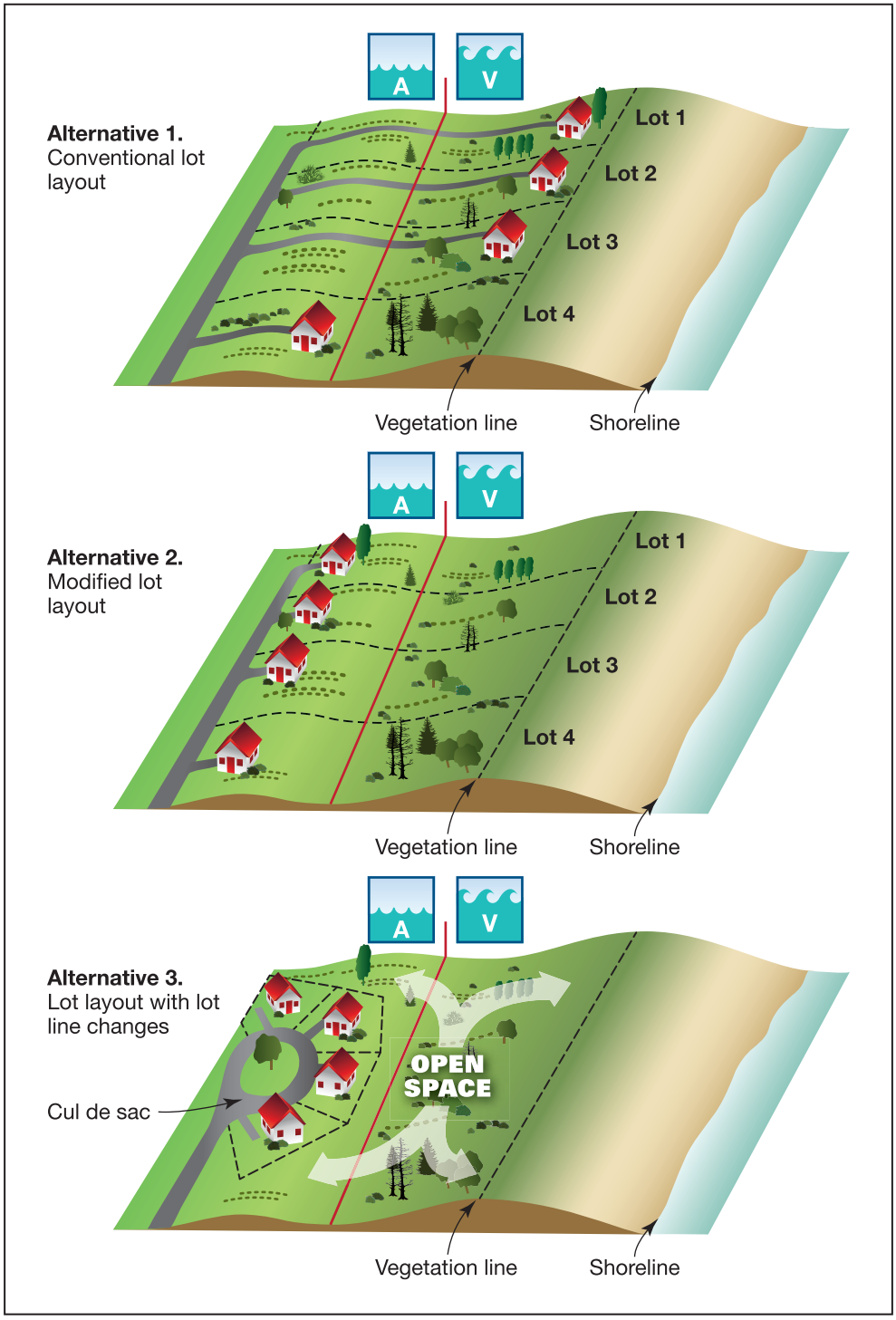


Figure 4-18.
Coastal lot development scenarios
SOURCE: ADAPTED FROM CALIFORNIA COASTAL COMMISSION 1994

Figure 4-19.
As buildings in this Humbolt County, CA, community are threatened by bluff erosion along the Pacific Ocean, they are moved to other sites on the jointly owned parcel

In extreme cases, entire communities have been threatened by erosion and have elected to relocate. For example, the village of Shishmaref, AK, voted in November 1998 to relocate their community of 600 after storm erosion threatened several houses and after previous shore protection efforts failed.

More information on specific examples of relocation of threatened buildings can be found in FEMA 257, *Mitigation of Flood and Erosion Damage to Residential Buildings in Coastal Areas* (FEMA 1994). The report also presents several examples of flood and erosion mitigation through other measures (e.g., elevation, foundation alterations).

4.5.3 Lot Configurations near Tidal Inlets, Bay Entrances, and River Mouths

Layout of lots and infrastructure along shorelines near tidal inlets, bay entrances, and river mouths is especially problematic. The three South Carolina houses in Figure 4-20 were built between January 1995 and January 1996, approximately 2 years before the photograph was taken in July 1997. They were built 100 or more feet landward of the vegetation line, but rapid erosion associated with a nearby tidal inlet left the houses standing on the beach only two years after construction. The shoreline will probably return to its former location, taking several years to do so. Although the buildings are structurally intact, their siting can be considered a failure.

CROSS REFERENCE

Section 3.5 also describes instances where the subdivision and development of oceanfront parcels near ocean-bay connections led to buildings being threatened by inlet-caused erosion.

Figure 4-21 shows condominiums built adjacent to the shore in Havre de Grace, MD, where the mouth of the Susquehanna River meets the head of the Chesapeake Bay. Although the buildings are elevated, they are subject to storm surge and flood-borne debris. Infrastructure development and lot layout in similar cases should be preceded by a detailed study of historical shoreline changes, including development of (at least) a conceptual model of shoreline changes. Potential future shoreline positions should be projected, and development should be sited sufficiently landward of any areas of persistent or cyclic shoreline erosion.

Figure 4-20.
Three 2-year-old South Carolina houses left standing on the beach as a result of rapid erosion associated with a nearby tidal inlet (July 1997)

Figure 4-21.
Condominiums built along the shoreline at the mouth of the Susquehanna River on the Chesapeake Bay were subjected to flood-borne debris after Hurricane Isabel (Havre de Grace, MD, 2003)

4.6 Development Guidelines for Existing Lots

Many of the principles discussed in the raw land scenario also apply to the construction or reconstruction of buildings on existing lots. Builders siting on a specific lot should take site dimensions, site features (e.g., topographic, drainage, soils, vegetation, sensitive resources), coastal hazards, and regulatory factors into consideration. However, several factors must be considered at the lot level; these are not a primary concern at the subdivision level:

- Buildable area limits imposed by lot-line setbacks, hazard setbacks, and sensitive resource protection requirements
- Effects of coastal hazards on lot stability
- Location and extent of supporting infrastructure, utility lines, septic tanks and drain fields, etc.
- Impervious area requirements for the lot
- Prior development of the lot
- Future building repairs, relocation, or protection
- Regulatory restrictions or requirements for on-site flood or erosion control

Although the local regulations, lot dimensions, and lot characteristics generally define the maximum allowable building footprint on a lot, designers should not assume that constructing a building to occupy the entire buildable area is a prudent siting decision. Designers should consider all the factors that can affect an owner's ability to use and maintain the building and site in the future (see Table 4-3).

Table 4-3. Guidelines for Siting Buildings on Existing Lots

Development or Redevelopment of Existing Lots in Coastal Areas: Summary of Guidelines for Siting Buildings	
DO determine whether the lot is suitable for its intended use; if not, alter the use to better suit the site or look at alternative sites.	**DON'T** assume engineering and architectural practices can mitigate poor lot layout or poor building siting.
DO study the lot thoroughly for all possible resource and hazard concerns – seek out all available information on hazards affecting the area and prior coastal hazard impacts on the lot.	**DON'T** assume that siting a new building in a previous building footprint or in line with adjacent buildings will protect the building against coastal hazards.
DO account for all types of erosion (e.g., long-term erosion, storm induced erosion, erosion due to inlets) and governing erosion control policies when selecting a lot and siting a building.	**DON'T** rely on existing (or planned) erosion or flood control structures to guarantee long-term stability of the lot.
DO avoid lots that require extensive grading to achieve a stable building footprint area.	**DON'T** overlook the constraints that site topography, infrastructure and ancillary structures (e.g., utility lines, septic tank drain fields, swimming pools), trees and sensitive resources, and adjacent development plane on site development, and (if necessary) future landward relocation of the building.
DO ensure that the proposed siting is consistent with local, regional, and state planning and zoning requirements.	**DON'T** overlook the constraints that building footprint size and location place on future work to repair, relocate or protect the building—allow for future construction equipment access and room to operate on the lot.
DO identify and avoid, or set back from, all sensitive resources.	**DON'T** overlook the effects to surface and groundwater hydrology from development of the lot.
DO consider existing public access to shoreline and resource areas.	

4.6.1 Building on Lots Close to Shoreline

Experience shows that just as developers should avoid certain subdivision development practices in hazardous coastal areas, they should also avoid certain individual lot siting and development practices. One of the most common siting errors is placing a building as close to the water as allowed by local and State regulations. Although such siting is permitted by law, it can lead to a variety of avoidable problems, including increased building vulnerability, damage to the building, and eventually encroachment onto a beach. On an eroding shoreline, this type of siting often results in the building owner being faced with one of three options: loss of the building, relocation of the building, or (if permitted) protection of the building through an erosion control measure. Alternatives to this practice include siting the building farther landward than required by minimum setbacks, and designing the building so it can be easily relocated. Siting a building farther landward also allows (in some cases) for the natural episodic cycle of dune building and storm erosion without jeopardizing the building itself. Siting a building too close to a coastal bluff edge can result in building damage or loss (see Figures 3-37 and 3-46, in Chapter 3). Keillor (1998) provides guidance regarding selecting appropriate construction setbacks for bluffs on the Great Lakes shorelines; these general concepts are applicable elsewhere.

Some sites present multiple hazards, which designers and owners may not realize without careful evaluation. Figure 4-22 shows northern California homes constructed along the Pacific shoreline at the top and bottom of a coastal bluff. These homes may be subject to several hazards, including storm waves and erosion, landslides, and earthquakes. Designers should consider all hazards and avoid them to the extent possible when siting a building.

Figure 4-22. Coastal building site in Aptos, CA, provides an example of a coastal building site subject to multiple hazards

SOURCE: CHERYL HAPKE, USGS, USED WITH PERMISSION

4.6.2 Siting near Erosion Control Structures

Siting a building too close to an erosion control structure, or failing to allow sufficient room for such a structure to be built, is another problematic siting practice. Figure 4-23 shows an example of buildings constructed near the shoreline behind a rock revetment. Although this revetment likely provided some protection to the buildings, they would have been better protected were they sited farther inland from the revetment. As shown in the figure, storm waves can easily overtop the revetment and damage the buildings.

CROSS REFERENCE

For more discussion on erosion and erosion control structures, see Section 3.5. Section 3.5.2.3 specifically discusses the effects of shore protection structures.

A related siting problem that is commonly observed along ocean shorelines as well as along bay or lake shorelines, canals, manmade islands, and marina/townhouse developments is the construction of buildings immediately adjacent to bulkheads. The bulkhead along the shoreline in front of the building in Figure 4-24 was completely destroyed from a subtropical storm. Had the building in the left of the photograph not been supported by an adequate pile foundation, it would likely have collapsed. Buildings sited close to an erosion control structure should not rely on the structure to prevent undermining. Bulkheads are rarely designed to withstand a severe coastal flood and are easily overtopped by floodwaters and waves. During severe storms, landward buildings receive little or no protection from the bulkheads. In fact, if such a bulkhead fails, the building foundation can be undermined and the building may be damaged or be a total loss.

Where buildings are constructed too close to an erosion control structure or immediately adjacent to bulkheads, it may be difficult to repair the erosion control structure in the future because of limitations on construction access and equipment operation. If erosion control structures are permitted and are employed, they should be sited far enough away from any nearby buildings to provide sufficient access to the site to complete repairs.

Figure 4-23.
Damage to buildings sited behind a rock revetment close to an eroding shoreline at Garden City Beach, SC (Hurricane Hugo, 1989)

Figure 4-24.
Beach erosion and damage due to a destroyed bulkhead at Bonita Beach, FL, from a subtropical storm
SOURCE: JUDSON HARVEY, JUNE 1982, USED WITH PERMISSION

4.6.3 Siting Adjacent to Large Trees

Although preservation of vegetation and landscaping are an important part of the siting process, designers should avoid siting and design practices that can lead to building damage. For example, designs that "notch" buildings and rooflines to accommodate the presence or placement of large trees should be avoided (see Figure 4-25). This siting practice may lead to avoidable damage to the roof and envelope during a high-wind event due to the unusual roof shape and additional sharp corners where wind pressure is greater.

Additionally, the potential consequences of siting a building immediately adjacent to existing large trees should be evaluated carefully. The condition and species of the existing trees should be considered. The combination of wind and rain can weaken diseased trees, causing large branches to become wind-borne debris during high-wind events. Some shallow-rooted species topple when their roots pull out of rain-saturated soils. Pine trees common to the southern United States are prone to snapping in half during high-wind events.

4.6.4 Siting of Pedestrian Access

The siting of pedestrian access between a coastal building and the shoreline often gets inadequate attention when siting decisions and plans are made. Experience shows, however, that uncontrolled access can damage coastal vegetation and landforms, providing weak points upon which storm forces act. Dune blowouts and breaches of these weak points during storms often result, and buildings landward of the weak points can be subject to increased flood, wave, erosion, or overwash effects. Several options exist for controlling pedestrian (and vehicular access) to shorelines. Guidance for the planning, layout, and construction of access structures and facilities can be found in a number of publications (additional dune walkover guidance is available on the FEMA Residential Coastal Construction Web page).

Figure 4-25. (below) Notching the building and roofline around a tree can lead to roof and envelope damage during a high-wind event

4.7 Influence of Beach Nourishment and Dune Restoration on Siting Decisions

Beach nourishment can be a means of mitigating potential adverse effects of shore protection structures. Beach nourishment and dune restoration can also be carried out alone, as a way of replacing beach or dune sediments already lost to erosion or of providing nourishment in anticipation of future erosion (National Research Council 1995).

Beach nourishment projects typically involve dredging or excavating hundreds of thousands to millions of cubic yards of sediment, and placing it along the shoreline. Beach nourishment projects are preferred over hardened erosion control structures by many States and communities, largely because the projects add sediment to the littoral system and provide recreational beach space.

The longevity of a beach nourishment project depends upon several factors: project length, project volume, native beach and borrow site sediment characteristics, background erosion rate, and the incidence and severity of storms following project implementation. Thus, most projects are designed to include an initial beach nourishment phase, followed by periodic maintenance nourishment (usually at an interval of 5 to 10 years).

WARNING

Beach nourishment and dune restoration projects are temporary. Although they can mitigate some storm and erosion effects, their presence should not be a substitute for sound siting, design, and construction practices.

The projects can provide protection against erosion and storm effects, but future protection is tied to a community's commitment to future maintenance efforts.

Beach nourishment projects are expensive and often controversial (the controversy usually arises over environmental concerns and the use of public monies to fund the projects). That controversy is beyond the scope of this Manual, but planning and construction of these projects can take years to carry out, and economic considerations usually restrict their use to densely populated shorelines. Therefore, as a general practice, designers and owners should not rely upon future beach nourishment to compensate for poor siting decisions.

As a practical matter, however, beach nourishment is the only viable option available to large, highly developed coastal communities, where both inland protection and preservation of the recreational beach are vital. Beach nourishment programs are ongoing in many of these communities and infill development and redevelopment continue landward of nourished beaches. Although nourishment programs reduce potential storm and erosion damage to inland development, they do not eliminate all damage, and sound siting, design, and construction practices must be followed.

Dune restoration projects typically involve placement of hundreds to tens of thousands of cubic yards of sediment along an existing or damaged dune. The projects can be carried out in concert with beach nourishment, or alone. Smaller projects may fill in gaps or blowouts caused by pedestrian traffic or minor storms, while large projects may reconstruct entire dune systems. Dune restoration projects are often accompanied by dune revegetation efforts in which native dune grasses or ground covers are planted to stabilize the dune against windblown erosion, and to trap additional windblown sediment.

WARNING

Although dune vegetation serves many valuable functions, such as stabilizing existing dunes and building new dunes, it is not very resistant to coastal flood and erosion forces.

The success of dune restoration and revegetation projects depends largely on the condition of the beach waterward of the dune. Property owners and designers are cautioned that the protection provided by dune restoration and revegetation projects along an eroding shoreline is short-lived—without a protective beach, high tides, high water levels, and minor storms will erode the dune and wash out most of the planted vegetation.

In some instances, new buildings have been sited such that there is not sufficient space waterward to construct and maintain a viable dune. In many instances, erosion has placed existing development in the same situation. A dune restoration project waterward of such structures will not be effective and therefore, those buildings in greatest need of protection will receive the least protection. Hence, as in the case of beach nourishment, dune restoration and revegetation should not be used as a substitute for proper siting, design, and construction practices.

4.8 Decision Time

The final step in evaluating a lot or parcel for potential development or redevelopment is to answer two questions:

1. Can the predicted risks be reduced through siting, design, and construction?

2. Are the residual risks to the site and building/development acceptable?

Unless both questions can be answered affirmatively, the property should be rejected (at least for its intended use) and other properties should be identified and evaluated. Alternatively, the intended use of the property might be modified so that it is consistent with predicted hazard effects and other constraints. Ultimately, however, reducing the long-term risks to coastal residential buildings requires comprehensive evaluation of the advantages and disadvantages of a given site based on sound siting practices as described in this chapter.

CROSS REFERENCE

Section 6.2.1 discusses reducing risk through design and construction. Chapter 6 also discussses residual risk.

4.9 References

California Coastal Commission. 1994. *Land Form Alteration Policy Guidance.*

FEMA (Federal Emergency Management Agency). 1994. *Mitigation of Flood and Erosion Damage to Residential Buildings in Coastal Areas*. FEMA 257. May.

Fulton, K. 1981. *A Manual for Researching Historical Coastal Erosion.* California Sea Grant Publication T-CSGCP-003.

Griggs, G. B. 1994. "California's Coastal Hazards." *Coastal Hazards – Perception, Susceptibility and Mitigation,* Special Issue No. 12. C. Finkl, ed. Prepared for the *Journal of Coastal Research, An International Forum for the Littoral Sciences.*

Keillor, J. P. 1998. *Coastal Processes Manual: How to Estimate the Conditions of Risk to Coastal Property from Extreme Lake Levels, Storms, and Erosion in the Great Lakes Basin.* WISCU-H-98-003. University of Wisconsin Sea Grant Institute.

Morris, M. 1997. *Subdivision Design in Flood Hazard Areas.* Planning Advisory Service Report Number 473. American Planning Association.

National Research Council. 1995. *Beach Nourishment and Protection.*

South Carolina Sea Grant Extension Program. 2001. *Questions and Answers on Purchasing Coastal Real Estate in South Carolina*. CR-003559. May.

Town of Nags Head. 1988. *Hurricane and Post-Storm Mitigation and Reconstruction Plan.*

Tuttle, D. 1987. "A Small Community's Response to Catastrophic Coastal Bluff Erosion." *Proceedings of the ASCE Specialty Conference, Coastal Zone '87.* American Society of Civil Engineers. New York.

University of Hawaii Sea Grant College Program. 2006. *Natural Hazard Considerations for Purchasing Coastal Real Estate in Hawai'i: A Practical Guide of Common Questions and Answers*. UNHI-SEAGRANT-BA-06-03. August.

University of Wisconsin Sea Grant Program. 2004. *Living on the Coast: Protecting Investments in Shore Property on the Great Lakes*.