CHAPTER 2

# Choosing an Optimal Site

This chapter explains how to choose an appropriate location for your Data Center, from the hazards you should avoid to the physical attributes you want. The chapter spells out the risks that can jeopardize a Data Center site, how to safeguard your server environment against them, and what agency to go to in order to learn if a specific parcel of land is susceptible. Finally, the chapter outlines what seemingly minor building elements can make or break a property's suitability to house a Data Center.

## Assessing Viable Locations for Your Data Center

When the time comes for your business to build a server environment, it is essential that the people responsible for the Data Center's design have an opportunity to provide input into where it is constructed. Traditionally, upper management decides what property to purchase, based upon a variety of a company's wants, needs, and business drivers. Other purchase considerations might include a parcel's price tag, its proximity to a talented labor pool, advantageous tax rates, or the desire to have a corporate presence in a particular geographic area. Whatever the drivers are, a property's suitability to house a Data Center must be among them. Purchasing or leasing a site without considering this greatly hampers the Data Center's capability to protect company servers and networking devices. Not making this a consideration also invariably leads to additional expense, either to retrofit the land's undesirable characteristics or to add more infrastructure to compensate for them.

An ideal Data Center location is one that offers many of the same qualities that a Data Center itself provides a company:

- Protection from hazards
- Easy accessibility
- Features that accommodate future growth and change

These qualities are fairly obvious, like saying that it is easier for an ice chest to keep drinks chilled when it is also cold outside. Less apparent are what specific characteristics improve or hamper a property's usability as a Data Center location and why.

## Building Codes and the Data Center Site

The first step when evaluating an undeveloped property's suitability as a Data Center site is a determination of how the property is zoned. Zoning controls whether a server environment is allowed to be built there at all. Zoning is done in a majority of countries and reflects how the local government expects a parcel of land to be used. Some classifications prohibit a Data Center.

Zoning information is maintained at the planning or public works department of the municipality whose jurisdiction the parcel is in. Many of these agencies even maintain their own websites and publish up-to-date zoning maps on them. Because land is frequently zoned in consistent blocks, a rudimentary way to estimate how a property is classified is to look at its neighbors. If the land is surrounded by private homes, it is probably residential. If the land is bordered by businesses or manufacturing, it is likely commercial or industrial. If the land is framed by open fields as far as the eye can see, it might be any of the previous zoning classifications or even agricultural land.

If a property you are interested in isn't zoned to allow a server environment, that doesn't mean you have to give up on the site. You can ask local government officials to rezone the parcel for a different type of use, although this might add time for them to review and approve your construction plans. As long as your construction project doesn't have a significant and negative impact on the surrounding area, it is likely to be approved.

Even if you are dealing with a developed site that contains existing structures, it is just as important to be familiar with the zoning, building codes, building control standards, and other government regulations (local, state, and national) that apply to the property. Ordinances vary significantly among cities, and even more so from country to country. They can regulate anything from how many hours a Data Center's standby generator is permitted to run per year to what time of day delivery trucks can travel through the neighborhood. Some countries even control the ratio of manpower and materials that can be imported, requiring that a project use a clear majority of in-country resources. Knowing the restrictions that apply to a given site enables you to either prepare for them or altogether avoid the location if you believe the rules aren't conducive to your business.

**NOTE** In early 2001, I helped plan an 8300 square-foot (771 square-meter) Data Center at an office site in Pleasanton, California. The property contained four buildings and was located in an area featuring small business parks and nearby residential neighborhoods. A major point of discussion with city planning officials focused on the proposed loading dock, which was to be in the same building as the Data Center and whose primary function was to receive incoming server equipment. The neighborhood had limitations on commercial truck travel, so Pleasanton representatives wanted detailed explanations of how much and what type of truck traffic the dock would incur. Fortunately, equipment deliveries were to occur infrequently, which allayed their concerns and enabled the project to move forward.

## Site Risk Factors

Every parcel of land comes with unique hazards. Knowing the hazards associated with any property upon which you consider placing a Data Center is very useful and should be a serious consideration. Maybe the site is in a region known for earthquakes. Maybe it is in a flood plain. Perhaps it is close to an electrical tower that generates electromagnetic interference. Regardless of whether the dangers are naturally occurring or man-made, it helps to understand how they can affect a server environment, how to alter your Data Center's design to prepare for them, and who can provide information about whether a hazard applies to a particular property. In many cases, the local planning or public works department is an excellent resource. Your company can also hire a risk management firm to gather applicable hazard information about a site.

As you read the descriptions that follow about various hazards and the suggestions for how to mitigate their influence, keep in mind that the absolute best way to avoid a threat to your Data Center is by keeping it out of harm's way altogether. If a property has multiple risk factors, your company needs to decide if the merits of the site outweigh the cost of additional infrastructure to compensate for those hazards and the possibility that a colossal disaster can still overwhelm those preparations.

### Natural Disasters

When considering risk factors connected to a property, most people think of natural disasters—catastrophes that devastate a broad geographic area. That's understandable. These events affect countless lives, do tremendous property damage, and garner significant media coverage. The following sections describe several that can threaten a potential Data Center location.

#### Seismic Activity

Earthquakes are caused when tectonic plates within the earth shift, releasing tremendous amounts of stored energy and transmitting powerful shock waves through the ground. The closer to the surface a shift occurs, the stronger the quake that is felt. Earthquakes are measured in two ways:

- Magnitude refers to its size, which remains the same no matter where you are or how strong the shaking is.
- Intensity refers to the shaking, and varies by location.

The most powerful earthquakes can topple buildings, buckle freeways, and cause secondary disasters, including fires, landslides, and flash floods—all extremely hazardous conditions that you want your Data Center to be well away from, or at least as insulated as possible against. Even a moderate quake that causes minimal property damage can tip over Data Center server cabinets, sever underground data cabling, or induce utility power outages.

Major earthquakes occur regularly around the world. Table 2-1 lists those of 7.5 magnitude or greater that have occurred just since the start of the 21st century, according to the United States Geological Survey.

**Table 2-1** *Recent Major Earthquakes*

| Date | Magnitude | Region |
|---|---|---|
| March 28, 2005 | 8.7 | Northern Sumatra, Indonesia |
| December 26, 2004 | 9.0 | West coast of northern Sumatra, Indonesia |
| December 23, 2004 | 8.1 | North of Macquarie Island, Antarctica |
| November 11, 2004 | 7.5 | Kepulauan Alor, Indonesia |
| November 17, 2003 | 7.8 | Rat Islands, Aleutian Islands, Alaska |
| September 25, 2003 | 8.3 | Hokkaido, Japan |
| August 4, 2003 | 7.5 | Scotia Sea |
| July 15, 2003 | 7.6 | Carlsberg Ridge |
| January 22, 2003 | 7.6 | Offshore Colima, Mexico |
| November 3, 2002 | 7.9 | Central Alaska |
| October 10, 2002 | 7.6 | Irian Jaya, Indonesia |
| September 8, 2002 | 7.6 | North coast of New Guinea |
| August 19, 2002 | 7.7 | South of Fiji Islands |
| August 19, 2002 | 7.7 | Fiji Region |
| March 5, 2002 | 7.5 | Mindanao, Philippines |
| November 14, 2001 | 7.8 | Qinghai-Xinjiang border, China |
| October 19, 2001 | 7.5 | Banda Sea |
| July 7, 2001 | 7.6 | Near the coast of Peru |
| June 23, 2001 | 8.4 | Near the coast of Peru |
| January 26, 2001 | 7.7 | Bhuj, India |
| January 13, 2001 | 7.6 | El Salvador |
| January 1, 2001 | 7.5 | Mindanao, Philippines |

Up-to-date listings of earthquakes around the world, major and minor, are available at http://neic.usgs.gov/.

If your Data Center site is in an area known for seismic activity, the entire building should be designed to lessen earthquake impacts. Limit the planned heights of buildings, consolidate weight onto the lowest floors, and use high-quality building materials that can withstand shaking and won't easily catch fire. Anchor the building's structure to the foundation and

use earthquake-resistant technologies such as steel frames and shear walls. Finally, limit the number of glass exterior walls and, no matter what architectural style is applied to the building, make sure that all balconies, chimneys, and exterior ornamentation are securely braced.

Similar earthquake mitigation should be applied within the Data Center itself, and more than one technique can be employed. One approach is structural reinforcement of all server and networking cabinets and their secure attachment to something immobile, by either bolting them directly to the Data Center subfloor or securing them with cables to anchor points set in to either the floor or ceiling. Alternatively, seismic isolation platforms can be installed below the cabinets. Bolting or tying the cabinets is intended to restrict their movement in a quake, whereas isolation platforms are to shift with an earthquake's motion, enabling the cabinets to surf over the movement and more likely stay upright.

Another good idea is the securing of all Data Center servers and networking devices by either tethering them with straps or directly mounting them to the cabinets. Miscellaneous Data Center supplies such as storage cabinets or tools should be tied down as well to reduce the number of objects that can become airborne in a quake. This both reduces the likelihood of injury to anyone in your Data Center during an earthquake and cuts down on how much debris has to be cleaned up once the shaking stops.

**NOTE** I've lived in California for more than 20 years and personally experienced several quakes, most notably the 6.9 magnitude Loma Prieta Earthquake in 1989 and 6.7 magnitude Northridge Earthquake in 1994. I can vouch firsthand that preparing for a quake ahead of time greatly reduces the damage and messes that are caused. As a newspaper reporter in 1994, I toured several structures that were moderately damaged during the Northridge Earthquake. The most common damage in private homes came from unsecured brick chimneys that pulled away from the house and collapsed. In office buildings, the quake's impact varied widely. In the same workspace, unrestrained bookcases and desktop computers were thrown more than 10 feet or 3 meters and smashed, while those tethered with safety straps moved only a few inches or centimeters.

When choosing among earthquake mitigation options, be conscious of how they affect your Data Center's design. Bolting cabinets reduces the room's flexibility, for example, while installing seismic isolation platforms means server rows need additional buffer space around them so that the platforms can shift from side to side during a quake.

How do you find out if a site you are interested in is prone to earthquakes? Maps showing seismic activity are available at the planning or public works department local to the property. These agencies also have relevant information about the parcel's overall geologic makeup. Land consisting of bedrock, for example, is more stable and therefore more desirable in a seismically active area than land consisting of soft soil. Additional information about seismic activity, from what to do in an earthquake to where major quakes have

occurred in the past, is also available through the United States Geological Survey, which you can find online at http://www.usgs.gov/.

### Ice Storms

When weather conditions are right, freezing rain can blanket a region with ice, making roads impassable and triggering widespread utility power outages for hundreds of square miles or kilometers. These ice storms occur when relative humidity is near 100 percent and alternating layers of cold and warm air form. Unlike some natural disasters that occur suddenly and dissipate, severe ice storms can last for days. Because they cover a huge area and make it difficult for repair crews to get around, it can take several weeks for normal utility service to be restored to an area.

If your Data Center site is in a region susceptible to ice storms, operate under the assumption that the room might need to run on standby power for extended periods of time and that contracted services for refueling your standby generator, assuming you have one, might be unreliable. Consider this when deciding what tier of infrastructure to build your Data Center to. Additional battery backups or standby generators with greater fuel capacity might be in order.

Be aware that the wintry cold that contributes to an ice storm can itself threaten your building's infrastructure. When temperatures approach 32° Fahrenheit (0° Celsius), ice blockages can form within water pipes. High pressure then occurs between the blockage and an end faucet or valve, which can cause the pipe to burst. Because the liquid inside is frozen, a break in a pipe might go unnoticed until it thaws. Thoroughly insulate your building's piping and perform regular maintenance to reduce the likelihood of a burst pipe.

**NOTE** More than once, I've encountered a Data Center overheating despite—and actually because of—frosty outdoor temperatures. One of these instances occurred during an early winter morning in 2002 in a small server environment that I helped support in Wuppertal, Germany. Chilly outdoor temperatures caused water that was normally produced by the air conditioning system to ice up overnight, which made the system shut down. Once the Data Center's sole air handler was offline, the temperatures in the room skyrocketed. Fortunately, the server environment was monitored by sensors programmed to set off an alarm if ambient temperatures reached 90° Fahrenheit (32.2° Celsius). Local support staff responded to the alarm by propping open the Data Center's door, setting up large pedestal fans, and blowing in cold air that was conveniently available from outside. Their actions moderated the room's temperature until a technician arrived, cleared ice from the air conditioning system, and restarted the air handler.

Local meteorologists as well as those in the planning or public works department can tell you if a property is susceptible to ice storms or freezing temperatures.

## Hurricanes

Hurricanes, alternatively known in parts of the world as tropical cyclones or typhoons, are severe tropical storms capable of generating winds up to 160 miles per hour (257.5 kilometers per hour). (A tropical storm is not officially considered a hurricane until its winds reach at least 74 miles per hour [119.1 kilometers per hour].) Hurricanes form over all of the world's tropical oceans except for the South Atlantic and Southeastern Pacific. Although they do not start on land, powerful hurricanes have been known to come inland for hundreds of miles or kilometers before dissipating, causing widespread utility power outages and sometimes spawning tornadoes. Hurricane season begins in mid-May in the eastern and central Pacific basin and in June in the Atlantic basin, including the Gulf of Mexico and Caribbean Sea, and ends in November.

If your Data Center site might be in the path of a hurricane in the future, design the room without exterior windows. Transparent views into your server environment are not a good idea at any time, because they create an unnecessary security risk, and should especially be avoided should the building be struck by a hurricane. A hurricane's high winds can propel large debris through a glass window, even one that has been taped or boarded over.

Locate the server environment at the center of the building, if possible, and surround it with cement interior walls. If the Data Center must be near an external wall, surround it with a service corridor. All of your site's major infrastructure components should likewise be sheltered to withstand high winds.

Additionally, because hurricanes often cause power failures that last for days, design your Data Center with adequate standby power to continue functioning for that long. (Chapter 6, "Creating a Robust Electrical System," includes details about providing a Data Center with backup power.)

Besides high winds, hurricanes carry tremendous amounts of water. If a hurricane passes anywhere in the vicinity of your Data Center site, there is an increased chance of moisture entering the buildings there. For instance, external air vents on a building are typically oriented downward and covered with a protective lip. Although this is sufficient to keep out moisture from even a heavy rainstorm, a storm driven by hurricane winds projects water in all directions—including up into a downward-facing vent. Install additional barriers in the Data Center building to make it more water resistant. Consider having a subroof, for example, that can continue to protect the Data Center if a storm damages the main roof.

Hurricanes are unlikely to be a risk factor for a property if it is well inland. However, local meteorologists can tell you for certain if a property has a history of hurricane activity.

## Tornadoes

A tornado is an intense rotating column of air. Created by thunderstorms and fed by warm, humid air, they extend from the base of a storm cloud to the ground. They contain winds up to 300 miles per hour (482.8 kilometers per hour), and can inflict great swaths of damage 50 miles (80.5 kilometers) long and more than a mile (1.6 kilometers) wide. Tornadoes

can cause significant property damage, trigger utility power outages, and generate large hail. The most powerful tornadoes are capable of throwing cars and other large debris great distances, leveling homes, and even stripping bark off of trees.

If your Data Center site is in an area where tornadoes occur, it should be designed with the same safeguards as for a hurricane—avoid external windows on the Data Center and provide enough standby power systems to do without commercial power for extended periods of time.

Tornadoes can form any time of year. They occur predominantly in the United States, but are also known to appear in Australia and Europe. A portion of the central United States, roughly bordered east and west between the Appalachians and Rocky Mountains and north and south from Nebraska and Iowa to central Texas, is nicknamed Tornado Alley because of the high frequency of tornadoes. Local meteorologists can tell you if a property is susceptible to tornadoes.

### Flooding

Flooding most often occurs because of torrential rains. The rains either cause rivers and oceans to rise dramatically and threaten nearby structures or else trigger flash flooding in places with non-absorbent terrain, such as pavement, hard-packed dirt, or already saturated soil. Although less frequent, flooding can also occur from a break in a dam or other water control system. Severe flooding can uproot trees and move parked cars, breach walls, and make roadways impassable. Flooding can also trigger utility outages and cause landslides.

If your Data Center site is in an area prone to flooding, make sure that the building's walls are watertight, reinforce the structure to resist water pressure, and build on elevated ground. If the property has no elevated ground, then consider building the Data Center above the ground floor. This keeps your company's most important equipment out of harm's way if water does reach the structure.

Placing the Data Center above the ground floor, however, affects other elements of the building's design. First, a building's weight-bearing capability is less on its upper levels than the ground floor. To compensate for this, either structurally reinforce the Data Center area or else accept significant limitations upon the acceptable weight of incoming server equipment. Current trends in server design are for more compact form factors that make for heavier weight loads, so in most instances reinforcement is the better option.

Second, if the Data Center is not on the ground floor, the building must have a freight elevator to accommodate incoming equipment and supplies. The elevator must be tall, wide, and deep enough to accept server cabinets, tape libraries, or pallets of materials. The elevator must also have the ability to support the equipment's weight as well as that of the pallet jack and people transporting them.

To find out if a property is located in a flood plain, contact the local planning or public works department. In the United States, flood plain information is also maintained at local

offices of the Federal Emergency Management Agency (http://www.fema.gov/). The agency's Technical Services Division performs hydrologic and hydraulic analyses to identify flooding hazards in communities throughout the United States.

### Landslides

A landslide occurs when a hill or other major ground slope collapses, bringing rock, dirt, mud, or other debris sliding down to lower ground. These flows can cause significant property damage, either in a single fast-moving event or gradually over time. Slides, also known as earthflows or mudflows, are propelled by gravity and occur when inclined earth is no longer stable enough to resist its downward pull. Earthquakes, heavy rainfall, soil erosion, and volcanic eruptions commonly trigger landslides.

If your Data Center site is in an area prone to slides, the environment should be designed with safeguards similar to those for flooding—make exterior walls watertight and strong to withstand sliding muck and debris and build on elevated ground. Other advisable practices are the construction of a retention wall or channel to direct flows around the Data Center building and the planting of groundcover on nearby slopes.

Parcels at the base of a steep slope, drainage channel, or developed hillside are more susceptible to landslides. Slopes that contain no vegetation, such as those burned by fire, are also more vulnerable to them. Trees, fences, power lines, walls, or other structures that are tilted on a site might be an indication of a gradual slide. Local geologists as well as those in the planning or public works department can tell you whether a particular property is vulnerable to landsliding.

### Fire

Fires are the most common of natural disasters. They cause significant property damage, spread quickly, and can be started by anything from faulty wiring to lightning strikes to intentional arson. Even a coffee maker in a break room is a potential source of a fire. Large fires can span tens of thousands of acres and threaten numerous buildings. Even the act of extinguishing a fire once it has entered a structure can lead to millions of dollars in losses from water damage. Additionally, a fire that fails to reach your Data Center can still cause problems. Minor amounts of smoke from a blaze can clog the sensitive mechanisms within servers and networking devices, causing them to malfunction later.

The best ways to deal with fire in the design of your Data Center are prevention and early detection. Install fire-resistant walls and doors, smoke detection devices, and fire suppression systems, both in the Data Center and throughout the building. (Fire suppression system options for a Data Center are outlined in Chapter 8, "Keeping It Cool.") It is also desirable for the building to have adjustable dampers on its ventilation and air conditioning system. This enables you to prevent outside air from entering the server environment during a nearby brush or building fire.

Once your server environment is online, remove potential fuel for a fire by equipping the room with fireproof trash cans and prohibiting combustible materials in the Data Center such as cardboard. Be sure to keep brush and other flammable items cleared away from the building, too.

**NOTE** There are mixed opinions among building agencies and firefighting organizations about the value of landscaping with "fire-resistant" vegetation. Some people believe that this practice is beneficial, while others point out that high-intensity fires burn any plants, regardless of type.

Although many causes of fires are unpredictable, the local fire department can tell you if a property has experienced wildfires in the past and where controlled burns are conducted in a region to eliminate unwanted brush.

## Pollution

Just as smoke particles from a fire can interfere with the proper functioning of servers and networking devices, so too can other airborne contaminants such as dust, pesticides, and industrial byproducts. Over time, these pollutants can cause server components to short-circuit or overheat.

If your Data Center is built in a region where contaminants are present, protect your equipment by limiting the amount of outside air that is cycled into the room. The percentage of external air that must be circulated into a Data Center is normally controlled by regional building codes or building control standards. The ratios of internal and external air are based upon the size of the server environment and its expected occupancy. A Data Center that has personnel working in it throughout the day is typically required to incorporate more outside air than a Data Center the staff of which are in the room less frequently. Some municipalities even allow zero external air if no employees work throughout the day in the server environment.

A second method of protecting your Data Center is incorporation of high efficiency air filtration into the environment's air conditioning system. Be sure to schedule frequent and regular filter changes for all Data Center air handlers.

**NOTE** Keeping away pollutants is also important if your Data Center is equipped with sensitive smoke detection devices. In October 2003, a brush fire came within several hundred yards of a Data Center that I manage in San Jose, California. Although the fire was never a threat to reach the Data Center, it registered on the room's smoke detection system. The system had to be quickly disabled to prevent it from releasing the Data Center's fire suppression agent.

Some municipalities have an agency responsible for managing regional air quality that can provide information about known sources of pollution in an area. Pay special attention to this risk factor in areas known for strong winds, since they are more likely to kick up dust or carry contaminants a significant distance.

## Electromagnetic Interference

Electromagnetic interference, or radio frequency interference, is when an electromagnetic field interrupts or degrades the normal operation of an electronic device. Such interference is generated on a small scale by everyday items ranging from cellular phones to fluorescent lights. Large sources of interference, such as telecommunication signal facilities, airports, or electrical railways, can interfere with Data Center servers and networking devices if they are in close proximity.

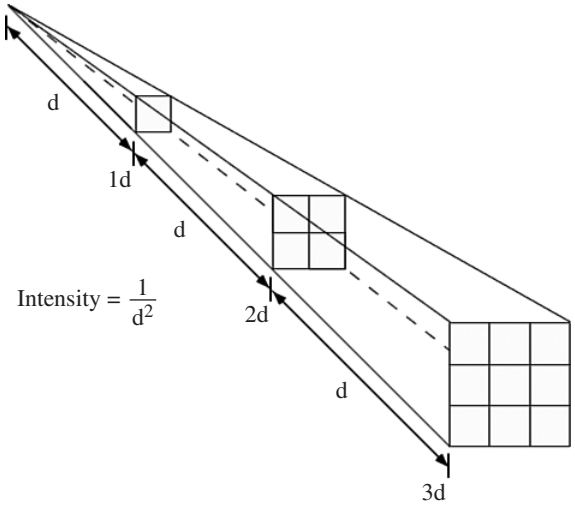
Electromagnetic interference is particularly challenging because it's not always easy to tell that your Data Center devices are being subjected to it. Even when that is known, you may not be able to immediately ascertain what the source of interference is. System administrators, network engineers, and others who work directly with the equipment are most likely to see symptoms first, even if they don't realize their cause. If you learn of a server experiencing unexplained data errors and standard troubleshooting doesn't resolve the problem, check around for possible sources of electromagnetic interference.

If your property is near an identified source of interference, locate the Data Center as far away as possible to limit the effects. All manner of shielding products—coatings, compounds, and metals; meshes, strips, and even metalized fabric—are available to block electromagnetic interference, but most of them are intended for use on individual devices rather than over a large Data Center. Again, distance from the source of interference is the best protection. That's because electromagnetic interference works according to the inverse square law of physics, which states that a quantity of something is inversely proportional to the square of the distance from a source point. The law applies to gravity, electric fields, light, sound, and radiation.

So, if a Data Center is located twice as far from a source of electromagnetic interference, it receives only 1/4 of the radiation. Likewise, if a Data Center is 10 times as far away, it receives only 1/100. To see an example of this effect, shine a flashlight (torch) against a wall. Back away from the wall, increasing the wall's distance from the light source (the mouth of the flashlight), and the circle of light against the wall becomes larger and fainter. Move closer, reducing the distance between wall and the light source, and that circle of light becomes smaller and more intense.

Figure 2-1 illustrates the inverse square law.

**Figure 2-1** *Inverse Square Law*




The intensity (I) of electromagnetic radiation is inversely proportional to the square of the distance (d) from the source.

The local planning or public works department can provide the location of airports, railways, and other facilities known to produce electromagnetic interference.

**NOTE** The first Data Center I ever worked in taught me how electromagnetic interference, together with a ramshackle environment, can harm a server. That Data Center began as a networking closet, was outfitted with the infrastructure necessary to host servers, and then expanded as needed to accommodate more devices. Because the room grew piecemeal, and wasn't designed to be a Data Center in the first place, its footprint was irregular—squarish, but with multiple indentations from adjacent rooms. The odd shape created uneven server rows and caused its power distribution units, which provided power to those rows, to be installed wherever they could be shoehorned in, sometimes in less than ideal locations. Also, when the Data Center came online, there were no standards for what server cabinets or power strips could be used. As a result, power capacity varied widely from one server location to another. As time passed and various cabinets were used, it became increasingly difficult to know if installing a new server into a half-empty cabinet would trip a circuit breaker or not. To eliminate guesswork, an electrician was called in periodically to measure the power draw on the circuits that fed questionable cabinets.

The first hint of trouble appeared when a system administrator complained about a mysteriously malfunctioning server. It would operate correctly for weeks, then generate error messages. Replacing drives halted the problem, but only temporarily. When I examined the server, I discovered that it had been installed—incorrectly—at the end of a truncated server row, beyond (what was supposed to be) its final server cabinet location. This put it on a short diagonal, about three feet or one meter, to a power distribution unit.

Because the unit fed several of the cabinets with unknown electrical capacity, its circuits were often tested. Measuring the power draw on circuits required removing the power distribution unit's protective shielding, which meant we had been sporadically bathing the nearby server in electromagnetic interference. Small wonder that the device had malfunctioned, or that relocating the server cabinet immediately resolved the issue.

## Vibration

Servers and networking devices, like other complex and sensitive electronic equipment, are vulnerable to vibrations as well. As when dealing with electromagnetic interference, there are several commercial products available to inhibit vibrations from reaching Data Center servers—from springs to gel-filled mats to rubber mounts—but the most effective solution is simply avoid locating your Data Center near large vibration sources. Airports, railroads, major thoroughfares, industrial tools, and road construction are common sources of vibrations.

The local planning or public works department can provide information about what major road construction is scheduled to occur near a property, as well as which of these other facilities are in close proximity.

## Political Climates

Among the most challenging risk factors to diagnose and prepare a potential Data Center site for are the man-made kind. Political instability in a region can delay the delivery of Data Center equipment and materials, make utility services unreliable, and—worst of all—threaten the safety of employees. Depending upon how contentious conditions are, workers of certain nationalities might even be prohibited from traveling into the region.

When dealing in an area with conflict, adjust your Data Center project timelines to accommodate delays. Design the server environment itself with standby power systems to support the room if utility services fail. Reinforce building walls to withstand explosions. Install safety bollards around entrances and any external infrastructure, such as generators, to protect against someone ramming a vulnerable area with a car or truck. Consider placing security fencing around the entire site. To find out whether or not a property is in a politically unstable area, check with the local embassy and news outlets. The United States Department of State, Bureau of Consular Affairs (http://travel.state.gov/) issues travel warnings for known trouble spots, as do the consular offices of most countries.

**NOTE** I received an abject lesson in 2001 about the realities of working on a Data Center project in a politically unstable area. My team had created a design for a server environment under construction in South Natanya, Israel. Several weeks into the project, word went out that the son of one of the contractors on the project had just been killed. A nail bomb had exploded on a public bus that the young man was in the vicinity of.

### Flight Paths

If there's an airport in the region of a potential Data Center site, be aware of the flight paths that incoming and outgoing planes regularly follow. Although crashes or debris falling from aircraft are rare, the effect can be devastating if something does strike your Data Center.

How should you prepare for this unlikely event? Even if your property lies in the path of a busy airport, it is probably not cost effective to make your Data Center an impenetrable bunker. A more practical solution is to distribute your servers. Build two smaller server environments and place them in separate locations, even if just two different buildings on the same property. As unlikely as it is for your Data Center to be struck by an out-of-control plane, it is that much less likely for two rooms to suffer the same fate.

The local planning or public works department can inform you if a property is in the flight path of any local airports.

## Evaluating Physical Attributes of the Data Center Site

Once you are aware of the risk factors facing a potential Data Center site, it is time to assess the physical features of the property by answering the following questions:

- Where is the site?
- Is it easy to reach?
- Does it have existing structures?
- If so, how suited are they to housing a server environment?
- Specifically, how well does the site support the key design strategies for constructing a productive Data Center?

Remember, you want your Data Center to be robust, modular, flexible, standardized, and to intuitively promote good practices by users.

## Relative Location

There's an old saying in real estate that the three most important features about a property are location, location, location. The saying is equally true when evaluating a potential Data Center site, albeit for a different reason. Whereas a home buyer might care about location because of a residence's vicinity to a posh neighborhood, a Data Center designer cares because of how easy it is to reach the property and where it is in relation to the company's other server environments.

### Accessibility

When examining a property, make note of how easy it is to enter and leave by answering questions such as the following:

- Is the site visible from a major roadway?

- Are their multiple routes to reach the property or just one?
- Could a hazardous materials spill or major traffic accident at a single intersection block access to the site?

Treat the property's accessibility the same as other Data Center infrastructure details—look for redundancy and stay away from single points of failure.

An ideal Data Center site can be reached easily and has several means of ingress and egress. A property with limited access affects the everyday delivery of equipment, because large trucks might be unable to reach the site. Limited access also influences the response time for emergency service vehicles to reach the site in a crisis.

Finally, determine if the property is located near large population centers. This influences how close your employees live and therefore how long it might take someone to reach the Data Center after hours if an emergency occurs.

### Disaster Recovery Options

There are countless publications that thoroughly explain how and why to create a business continuation strategy for your company. While that topic isn't the focus of this book, it is a good idea to think about how a potential Data Center site fits in to your company's disaster recovery plan.

If your plan calls for transferring business functions from one Data Center to another, for example, note the distance between the property you are evaluating and your company's other server environments and answer the following questions:

- Are the locations close enough that network latency won't be a problem?
- Can employees travel from one site to another in a reasonable amount of time, even if major roadways are blocked or airline flights aren't operating normally?
- Are the locations far enough apart that they are both unlikely to be affected by a single disaster?

Likewise, if your company backs up information from the servers in your Data Center and stores the data tapes off-site, where are those facilities in relation to your potential Data Center property? The greater the distance between your Data Center and off-site storage facility, the longer it will take to retrieve and restore the data after a disaster.

## Pre-Existing Infrastructure

Many sites evaluated for housing a Data Center are at least partially developed, whether they have little more than an empty building shell or a fully equipped office building with a pre-existing server environment. Whatever the building was previously used for, diagnose if the infrastructure that's already in place can accommodate your needs or at least be retrofitted to do so. Important infrastructure considerations are

power systems, cooling systems, and structured cabling, as described in the sections that follow.

## Power Analysis

Assess the property's power systems, including its electrical infrastructure and standby systems by answering the following questions:

- How much power is readily available?
- Are there enough electrical circuits to support your Data Center?
- If not, is there enough physical capacity at the site to add more?
- Do power feeds come in to the building at more than one location?
- What alterations must be made to accommodate battery backup systems and standby generators?
- If the site already has standby systems, are they of sufficient capacity to support your Data Center?
- If the site doesn't have them, does it at least have the physical space and structural support for them to be installed?

Make note of how much redundancy is present in the electrical infrastructure and what single points of failure exist.

## Cooling Capabilities

Data Centers require significantly more cooling infrastructure than the equivalent amount of office space. Therefore, measuring the cooling capacity of a potential Data Center site is important. To assess the cooling capacity of the site, determine the following:

- Can the building's existing cooling infrastructure provide adequate cooling for a Data Center?
- Is there adequate space and structural support on the site to support air chillers, condenser units, or cooling towers?
- How much modification must be done to the building's existing air ducting to reroute cooling?

## Structured Cabling

Determine how much and what type of structured cabling already exists in and to the building. Determine if enough connections exist to support your Data Center and if cabling comes in to the building at more than one location.

Certain cabling media have distance limitations, so it is a good idea to measure how far cable runs must travel, both for the Data Center and throughout the building. Also make note of how much redundancy is present in the cabling infrastructure and what single points of failure exist.

## Amenities and Obstacles

Aside from whatever power, cooling, and cabling infrastructure a building already possesses, there are several less obvious features that make a structure more or less amenable for housing a Data Center, including the following:

- Clearances
- Weight issues
- Loading dock placement
- Freight elevator specifications
- Miscellaneous problem areas
- Distribution of key systems

Some of these elements can make a site completely unsuitable to housing a Data Center, while others are merely matters of convenience. The sections that follow examine these elements in greater detail.

### Clearances

One of the most basic features to examine about an existing structure is its physical dimensions. Some of the questions you need to answer about the site's dimensions are as follows:

- Is there enough contiguous floor space to house your Data Center?
- How tall are the doorways?
- How wide are the halls?
- What's the distance from floor to ceiling?

These dimensions all need to be sufficient to enable Data Center equipment to pass through easily.

The area for the Data Center itself normally requires a minimum of about 13 feet (4 meters) from floor to ceiling, and much more is preferable. The clearance is to accommodate the raised floor, the height of most server cabinets, the minimum buffer space between the cabinet and the room's drop ceiling that is typically required by local fire codes, and space above the drop ceiling where ducting is routed. Additional space

above the drop ceiling allows for easier and more effective cooling of the server environment—more area means that a greater volume of cold air can be pumped in to the Data Center—and so is desirable.

An unobstructed pathway must also exist among the Data Center, its corresponding storage room, and the exterior of the building, for transporting equipment. All entrances, corridors, doorways, and other openings along this path must be at least 8 feet (2.4 meters) high and at least 4 feet (1.2 meters) wide. These measurements are chosen to enable your tallest server cabinets and widest pallets of supplies to be transported within the building and into the server environment easily. If you have Data Center-related items that are larger in size, look for larger building clearances accordingly. That brand-new disk library you purchase to perform data backups can't do you much good if it does not fit through the Data Center doors.

### Weight Issues

Once you've determined whether server cabinets and pallets of materials can be transported without difficulty through the building, you need to make sure that none of them damage or crash through the floor. Consider the structural capacity of the building and how much weight the floor is designed to support, especially in the Data Center area. Pay particular attention to this if you intend to place the server environment on an upper level—their weight-bearing capability is normally less than on the ground floor.

### Loading Dock

Servers, cabinets, networking devices, or backup storage units can sometimes be damaged during transport to your Data Center. When this does happen, it is often attributed to the equipment being shaken while rolled across uneven ground or dragged over the lip of an entrance and having the item thump forcefully to the ground under its own weight. Although you can't control what happens during shipment, you can safeguard how equipment is treated once it arrives at your site.

Having a loading dock in close proximity to your Data Center reduces the chance of equipment damage, so it is very helpful if a property you are evaluating has one. Equipment can be rolled a short distance across level ground, either directly into the server environment or an associated storage room, rather than having to be offloaded from an elevated truck bed and shuttled a longer distance.

### Freight Elevators

As stated earlier in the chapter, a freight elevator is mandatory if your Data Center is located anywhere but on the ground floor. As with the doorways and corridors, the freight elevator must be at least 8 feet (2.4 meters) high and at least 4 feet (1.2 meters) wide so as to

accommodate everything from tall server cabinets to wide pallets of equipment. The freight elevator must also have enough weight-bearing capability to carry a fully loaded server cabinet. Today's heavier systems can exceed 1500 pounds per server cabinet location, and it is reasonable to assume that that number will increase.

If your company site doesn't have a suitable freight elevator, you might be forced to take drastic measures to bring large equipment in and out. Figure 2-2 shows workers raising a backup tape library six stories above the ground with ropes and pulleys, for its installation into a Data Center in Bangalore, India.

**Figure 2-2** *Moving Equipment Without a Freight Elevator*

Image provided by courtesy of Cyril Gnanaprakasham

The lack of a freight elevator in this building means that large equipment bound for the Data Center must be raised by hand.

Happily, the tape library was undamaged during transit. Ignoring for a moment the hazard that transporting a piece of equipment poses for the device itself, it is certainly potentially dangerous to those who participate. Look closely at Figure 2-2 and you can see that one of the workers is straddling the external stairwell railing as he helps pull on the rope to lift the equipment crate. When the time comes for the device to be removed from the Data Center, it will have to be lowered from the sixth floor in this same manner.

**NOTE** A passenger elevator is no substitute for a freight elevator, either. In August of 1998, I helped fitup a 12987 square-foot (1206 square-meter) Data Center in San Jose, California, that was located on the second floor of a building that had no freight elevator. The fitup stage includes all prep work that happens after major construction finishes and before the room comes online. Signage is installed, tools and supplies are stocked, and server cabinets are wheeled in.

The building's two passenger elevator cars were about 7 feet (2.1 meters) tall, shorter than the server cabinets used in the Data Center. With the help of a coworker, I had to tilt and steer each 155-pound cabinet into an elevator, support it at an angle during the ride to the second floor, and then wheel it in to the Data Center. Because the cabinet had to lean at a steep angle while in the elevator, only one person and one cabinet fit at a time. We spent an entire afternoon shuttling more than 100 cabinets up to the Data Center this way. While this was inconvenient to do with empty server cabinets, it would have been impossible to do with ones that were even partially loaded with servers. The building was retrofitted with a freight elevator several weeks later, at great cost and with the assistance of a helicopter to rip out the old lift.

## Problem Areas

A key reason to have someone with Data Center design and operation experience help evaluate a building is to identify inobvious trouble spots. Determining whether a structure has adequate infrastructure or tangible facilities such as a loading dock or freight elevator is a straightforward exercise; however, some buildings might have problem areas—from a Data Center perspective—that are not as easily noticed.

Carefully examine all aspects of the building, large and small, to ensure that nothing can interfere with the operation of a server environment. Consider issues such as the following:

- **Where are immovable building elements such as structural columns and stairwells?**—These might restrict how much floor space is usable for a Data Center.
- **Does the building have a kitchen or cafeteria?**—This is a potential fire hazard, and if a site has multiple structures, kitchens or cafeterias should be located in a different building from the Data Center.
- **Where are the building's water pipes?**—Plumbing can leak and therefore shouldn't be routed above the server environment.

## Distribution of Key Systems

As you examine the site's existing infrastructure, look closely at how the systems are configured. You ideally want important systems, such as power feeds and data cabling, to be spread out, each entering the building at more than one location. Such physical

separation helps protect infrastructure systems—two cable runs following different paths are less likely to both be damaged by a single event than if they each follow the same path, for example. Standby power systems such as generators or backup batteries make the site more robust, and are even more beneficial if they are dispersed on a property rather than clustered together.

## Confirming Service Availability to the Data Center Site

Arguably more important than what infrastructure already exists at a potential Data Center site are what utility services can be provided to it. It is fairly simple to have a contractor come out and install data cabling if a property lacks it, for example, but you still can't communicate with the outside world if there's no service provider offering connectivity. Make sure that the property has—or can be provided with—adequate power and data connections for the Data Center, along with the standard water, telephone, gas, and other utilities that any office environment requires.

Aside from power outages that can be caused by natural disasters, some parts of the world simply have less reliable electrical infrastructure than others. Brownouts or momentary dips in power might be common in these regions, which increases the need for your Data Center to have dependable standby power. Just as a car engine undergoes the most stress when it is first started, so too does a standby power system experience the most strain when a server environment's electrical load is first placed upon it. Frequently cranking a car's engine—or transferring a Data Center's electrical load—causes much more wear and tear than if the same equipment ran continuously for an extended time.

**NOTE** If you are reviewing a potential Data Center site that's in a large city with well-developed infrastructure, it is easy to assume that commercial power is abundant and reliable. *Don't*. During the first three months of 2001, 6 of the 10 California-based Data Centers that I manage were forced to run on standby power multiple times due to rolling blackouts. The outages, each lasting 90 to 120 minutes, were mandated by the California Independent System Operator to manage electricity shortages in the state. Rolling blackouts reduce electrical demand and are intended to prevent a drop in system frequency that can damage transformers or switching gear and therefore cause much longer, unplanned outages. At the peak of the blackouts, I had Data Centers in the cities of Petaluma, San Jose, and Santa Cruz—93 miles (150 kilometers) apart as the crow flies—lose utility power within 24-hours.

The repeated power transfers took their toll. During one outage, a logic board in an uninterruptible power source failed, preventing the standby power system from holding the Data Center's power load. Several dozen servers abruptly shut down as a result.

The corresponding local service providers can tell you what power and data lines exist on and around a property. When talking to the electric company, ask if it is possible to have the Data Center fed by more than one substation or power grid, thereby providing your facility with another layer of redundancy. When talking to the Internet service provider, determine what types and quantities of cabling are in the ground, both on the property and in the surrounding area.

## Prioritizing Needs for the Data Center Site

As you review potential Data Center sites, you'll find that there are no perfect properties, that is, parcels with zero risk factors, all of the physical features you want, and the specific types and amounts of infrastructure you are looking for. Many properties are completely inappropriate for housing a Data Center, while even the most suitable are a mixed bag. Perhaps a site is in a seismically stable area and well away from sources of pollution, electromagnetic interference, and vibration, but is vulnerable to hurricanes or tornadoes. Maybe a property has an existing building that's easily accessible and possesses adequate electrical capacity and incoming data connectivity, but has no loading dock. Whatever the details, all parcels have their unique features and conditions, advantages and drawbacks.

Prioritize what characteristics are most important based upon the specific needs of your company. If you know your business uses large, floor-standing servers, for example, then a building with ample clearances and a loading dock is essential. If your business strictly employs high-density, low-profile servers, then those characteristics are less valuable than a building with abundant cooling capacity and available electrical circuits. Both scenarios, however, require a structure with high weight tolerances.

During the process of selecting a site, you have to answer the Data Center design version of "which came first, the chicken or the egg?" In this case, the question involves a property's risk factors versus your Data Center's infrastructure. Do you opt to add extra layers of infrastructure because the Data Center must be built in a more hazardous area, or do you agree to build in a more hazardous area because the room is equipped with additional infrastructure? You might be less concerned with locating your server environment in a region with less reliable commercial power if you already plan to build a Data Center with 3N standby power, for example.

## Summary

When a company buys new land, it is important to consider the property's suitability to house a server environment. Failing to do so often means having to spend more on Data Center infrastructure, either to add what's missing or to overcome shortcomings on the site. The most desirable type of location is one that supports the Data Center's mission to safeguard server equipment and accommodate growth and change.

Learn the zoning, building codes, building control standards, and other regulations that apply to a property. These can affect both your Data Center design and normal business operations. You should likewise understand the risk factors facing a potential Data Center site. These can include natural disasters such as earthquakes, ice storms, hurricanes, tornadoes, flooding, and landslides, as well as fire, pollution, electromagnetic interference, vibration, political climates, or airport flight paths. If you decide to build in a region susceptible to these hazards, you need to adjust how the Data Center is designed, such as upping the capacity of its standby power systems or increasing the structural strength of the building, depending upon the particular threat that's posed.

An ideal Data Center location is strategically placed among your company's other Data Centers and any designated off-site storage facilities—close enough so employees can quickly reach them after a disaster, but far enough away that they are unlikely to all be affected by a single catastrophic event.

When evaluating a property, assess the physical features of all existing buildings. Determine what power, cooling, and data cabling already exist and how easily their capacity can be increased to support a Data Center. Also make sure that the structure has adequate clearance and weight-bearing ability to accept incoming server equipment. A loading dock, freight elevator, and distributed infrastructure all make a site more conducive for housing a Data Center, while immovable building elements and potential hazards such as water piping and a kitchen are unfavorable. Finally, confirm with local service providers that adequate power and connectivity can be provided to support the Data Center.

Because each property has its own advantages and disadvantages, you must decide what characteristics are most important for your business and choose accordingly.