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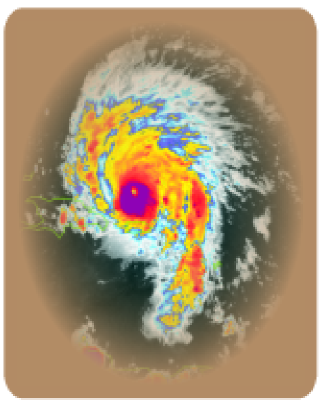
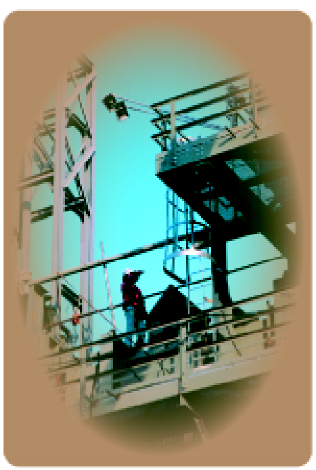
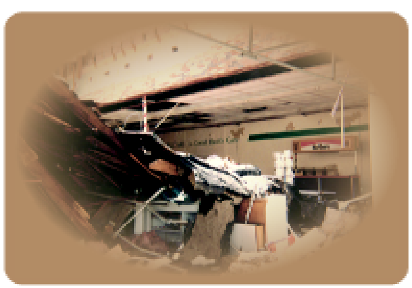
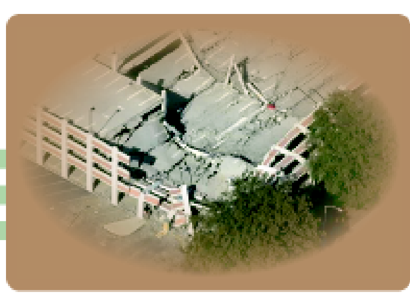
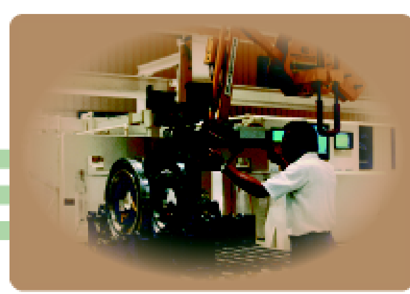
Protecting Business Operations



Second Report on Costs and Benefits of Natural Hazard Mitigation

August 1998

Protecting Business Operations

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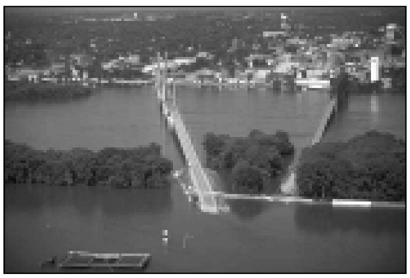
Table of Contents

Introduction



Flood waters can submerge critical equipment, hurricane force winds can rip sections of roofing off production facilities, and earthquakes can bring down suspended ceilings in office facilities. No matter where in the United States a business is located, natural hazards have the potential for shutting down a business for days, weeks, or more. Mitigation, which refers to prevention or loss reduction measures, is an important means of protecting business operations from the effects of natural hazard events. The case studies contained in this report highlight mitigation measures that have been implemented within the private sector.

From the most expensive disaster ever in the United States, the Northridge earthquake of 1994, to record flooding in the Red River Valley in 1997, to the unprecedented ice storms and tragic tornadoes of 1998, the staggering cost of natural disasters has risen drastically over the last decade. The Federal Emergency Management Agency's (FEMA) expenditures for disaster relief between 1989 and 1998 totaled over $21 billion. For the ten years previous to 1989, the total expenditures were only $4 billion.

Disaster expenditures are not exclusive to FEMA or the other Federal, State, and local government agencies. Businesses have been hit by disaster expenditures and losses as well. For example, during a 1997 flood, Newport Steel Corporation reported a $4 million loss in sales when it lost production of 8,000 tons of pipeline in one of its plants. Flooding in one of its mills caused $750,000 in property damages.[1]

With competitive markets, tight overhead, and slim profit margins, losses due to natural hazards can make the critical difference in a business' ability to maintain profitability, or even survive, after a natural disaster. Fortunately, natural hazard mitigation is a cost-effective method to reduce or even prevent losses, especially when it is integrated into the way the business operates. For example, mitigation measures only increase construction costs for new facilities between 1 and 5 percent. Rehabilitating existing facilities for seismic risks may cost up to five times more than the cost to build new facilities with measures that protect them against earthquake damage. Yet even

[1] Sekhri, Rajiv, "Flood Washes Out $4 million in Sales at Steel Maker," *Cincinnati Business Courier*, March 24, 1997, p. 11.

with the increased cost, retrofitting existing facilities may protect the facility from damages that far exceed the cost.[2]

The benefits to businesses from mitigation are not limited to a reduction in facility damages. The far-reaching benefits include:

- increased life safety for employees and customers,
- reduced down-time in production,
- reduced damage to inventory or supplies,
- protected information systems,
- reduced damages to facilities and nonstructural components,
- reduced damages to vital equipment, and
- enhanced insurance coverage or reduced insurance deductibles.

There is a range of options for preventing damages in existing or new facilities. It is up to a business to determine the level of protection necessary for its operations and the right mitigation measure to provide the protection. Mitigation actions that have shown to be cost-effective for businesses include:

- selecting property less vulnerable to natural hazards,
- building facilities to design standards that lessen the effects of earthquakes, floods, hurricanes and tornadoes,
- reinforcing building components that can fall or break during an earthquake or high wind event,
- preventing high winds and waters from entering the facility,
- elevating buildings or critical equipment above potential flood levels,
- relocating buildings to property not prone to flooding, and
- hardening lifeline systems to prevent damage during earthquakes or hurricanes.

In integrating mitigation into its operations, a business can determine the appropriate approach through a step-by-step process: assess the types of risks that threaten their operations; review existing and proposed facilities to determine their vulnerability to these risks; develop loss estimates; identify effective mitigation options and

[2] Tornese, Judith M. and Virginia Lawson, "Earthquakes Outside California; Rocking and Rolling," Risk Management, v44, n5, p21, May 1997.

their costs; make decisions to address the vulnerability based on the potential costs and benefits, and; implement the mitigation measures with approval from senior management.

Using this basic process, the businesses highlighted in the following case studies have reduced their risks to natural hazards. The businesses that have been subjected to a natural hazard event since taking mitigation action have benefited from substantial returns on their investment. For all of the businesses, their implementation of mitigation actions is not static. Due to the realized or anticipated returns on mitigation, these businesses are continuing to expand their use of mitigation to protect their business operations.

Case Studies

Warner Bros. Studios: Increasing the ability to get "Back into Business"

Warner Bros. Studios, a Time Warner Entertainment Company, has been "entertaining the world" for over 75 years, with such classic films as "The Jazz Singer," "Casablanca" and "The Maltese Falcom" to such contemporary award-winning and box office hits as "Batman," "Driving Miss Daisy," "Unforgiven," "The Fugitive" and such current hit series as "ER", "Friends" and "The Rosie O'Donnell Show." Warner Bros. stands at the forefront of every aspect of the entertainment industry from feature files to television, home video, animation, product licensing, retail stores and international theme parks. The company's main motion picture and television production facility is Warner Bros. Studios, located on 110 acres in Burbank, California, where from 5,000 to 10,000 people work on any given day.

Warner Bros. Studios' record of success goes beyond the actual movies and television shows produced. Its intelligent and savvy management practices have extended to its approach to reducing the effects of natural hazards. Warner Bros. Studios has been active in preventing costly natural hazard damages through preparedness and mitigation measures.

Warner Bros. Studios saved over $1 million in losses during the 1994 Northridge Earthquake. Needless to say, the mitigation program is now a regular budgetary expense.

Earthquake and severe weather hazards

Over the last ten years, the Burbank area has experienced many small and a number of moderate earthquakes. Two of the most notable were the 1987 Whittier Narrows earthquake, measured at 5.9 on the Richter Scale, and the 1994 Northridge earthquake, measured at 6.8. These earthquakes made Warner Bros. Studios especially cognizant of the potential for earthquake damage that could cause serious business interruption.

In addition, Warner Bros. Studios' Burbank facility is adjacent to the Los Angeles River. In the event of severe rain storms, surface ground water is prone to accumulate and overwhelm the area's usually suffi-cient drainage system. Each El Niño season, approximately every eight years, Warner Bros. Studios is at an increased risk of ground water flooding.

In recognition of the severe impact a natural hazard could have on its business operations, Warner Bros. Studios established an Office of Emergency Services in 1987. Over the years, Warner Bros. Studios has expanded its emergency services operation beyond preparedness activities to preventing the damage through mitigation measures.

In 1992, after an extensive cost-benefit analysis and a review of damages suffered by companies with similar types of buildings and environments during the Whittier Narrows and Loma Prieta earthquakes, mitigation became a separate Emergency Services' program for the company. The review demonstrated the potential damages that would directly affect the company's ability to get "back into business" in the aftermath of a moderate to large earthquake.

The earthquake mitigation pay-off

In 1993, non-structural hazard mitigation work began with fastening of PC's, furniture and shelving systems to avoid damage in a seismic event, with priority then being given to life safety, exits, and applications of heavy duty film to windows. In January 1994, the Northridge earthquake struck the area in the early morning of the Martin Luther King, Jr. Day holiday. Warner Bros. Studios' After Action Report estimated that the mitigation actions saved the company over $1 million in potential losses. Needless to say, the mitigation program is now a regular budgetary expense.

Beating El Niño

Warner Bros. Studios employees remembered the last El Niño season. Therefore, when similar weather patterns were forecast for the 1997-1998 El Niño, Warner Bros. Studios marshaled its staff to prepare for and prevent damages. Its Office of Emergency Services viewed the upcoming El Niño season as an opportunity to establish and update various logistical and prevention measures.

In late July 1997, the Office of Emergency Services held a "training moment." The session brought together, among others, staff who had been at the facility during the previous El Niño season. The group brainstormed on "white boards" the location and nature of the damages sustained during the prior El Niño season. Subcommittees were formed to identify action items to prevent these damages. The list of actions were prioritized by management and implemented. For example, they developed their own flood hazard map for their facility. Precautions were taken in the more vulnerable areas, and drains were checked weekly to ensure their functionality in the event of storm groundwater. Additionally, over 2,500 sandbags were stockpiled.

The establishment of pre-disaster purchase orders was also seen as an important preparedness activity. In order to ensure an adequate supply of post-disaster supplies during the El Niño season, pre-disaster purchase orders were established with 40 vendors.

As a result of the El Niño preparations, Warner Bros. Studios:

- reduced damages from severe storms generated by El Niño,
- developed pre-disaster purchase orders with critical vendors that will benefit the company beyond this El Niño season, and
- heightened the awareness and understanding of its Office of Emergency Services' role in preventing and responding to natural hazards.

Sharing the mitigation message

Warner Bros. Studios has reached out to their community to share their experience with natural hazards preparedness and mitigation. Its Office of Emergency Services has participated in community preparedness training in Burbank and West Hollywood. They view this community outreach as important to preserving the community infrastructure where their employees not only work but also live.

Due to nature of their business, the entertainment industry, Warner Bros. Studios has been able to reach consumers throughout the nation with the importance of preparedness. When Warner Bros. Studios released its box office hit movie Twister on video cassette, FEMA produced and distributed over 100,000 copies of a multi-hazard preparedness video entitled "Prepare...to Survive." The video was free when renting the Twister movie at video stores through out the country.

That's all folks!

Warner Bros. Studios' preparedness and mitigation efforts have reduced damage costs and brought increased sustainability in the event of a natural hazard. The impressive results from their effort are attributed to the strong support of senior management, and their proactive and multi-hazard approach. In the event of future natural disasters, Warner Bros. Studios' Office of Emergency Services is ready to reduce the impact of a disaster on their business operations.

BellSouth: Hardening Telecom Networks Against Storms

BellSouth is a regional voice and data communication company covering the southeastern United States. Across the nine-state BellSouth territory, families and businesses depend on the company for over 23 access lines and 4 million accounts that provide uninterrupted voice and data communications. BellSouth has over $36 billion in assets to operate these services that generate over $20 million in annual revenue. In 1997, BellSouth ranked first in industry productivity, and received the highest customer satisfaction ranking from J.D. Power and Associates Residential Local Telephone Customer Satisfaction Study.[3]

To maintain its high standard of productivity and customer satisfaction, Bellsouth has engineered a variety of mitigation measures into its network.

To maintain this high standard of productivity and customer satisfaction, BellSouth has engineered a variety of mitigation measures into its network—measures that have been well tested by hurricanes such as Hurricane Fran in 1996. BellSouth's experience is instructive for the growing number of companies with large investments in network infrastructure, such as power utilities, local and long-distance telephone companies, internet service providers, and financial services companies.

Hurricane threat in the BellSouth territory

More than any other region of the United States, the BellSouth coverage area is often battered by hurricanes and tropical storms. In fact, thirteen of the fifteen most powerful U.S. hurricanes this century struck one or more states within BellSouth's service area.[4] These storms pose a costly challenge for companies that, like BellSouth, strive to provide uninterrupted communications service to their customers.

Hurricane damages to communications networks include wind and water damage to facilities and electronics. A particularly vulnerable part of the network is the cables carrying signals and electrical power. Wind can rip wires from the sides of homes and blow over utility poles. Trees can fall across telephone lines, and the weight of freezing rain can pull them down. And even where telephone lines themselves remain intact, service can be interrupted by an electrical power outage.

3 http://www.bellsouthcorp.com/investor/annualreport97 on 3/29/98.
4 MultiHazard Identification and Risk Assessment, FEMA 1997

Ensuring telephone service for millions of customers

BellSouth addresses these storm threats by building reliability into the design of its network infrastructure. BellSouth's engineering efforts address each of the four most critical and vulnerable elements of the network: the central office, whose telephone switches may link an entire town or part of a city to a main trunk; the subscriberloop carrier or "SLC," a kind of hub that links an area such as a neighborhood to the central office; the cabling between central offices and SLC's; and the electrical power supplying each of these elements.

Protecting cables

Cables suspended between telephone poles or towers are vulnerable to falling trees, wind-blown debris, and the weight of ice formation. To avoid these dangers, BellSouth buries as much of its distribution network as possible. For example, in Wilmington, North Carolina, an area heavily damaged by Hurricane Fran, over 90% of the network is currently underground, and this proportion is increasing.

BellSouth has also been replacing its old copper cabling with fiber optic cable. Fiber optic cable provides more capacity for a competitive price compared to the cost of the old copper cables. Fiber optic cables not only provide increased capacity and quality, they are more reliable. During Hurricane Hugo, the first real test of BellSouth's investment in fiber optic cables, there were cases of fiber optic cables actually holding up fallen oak trees and still operating. If a fiber optic cable does break, the breakage is able to be repaired remarkably more quickly and more easily than with the copper cables.

Redundant links to the telephone network

Wireline telephone traffic is routed through the switches in central offices. If a central office were to lose its connection to the telephone network, thousands of households and businesses could be affected. To protect the central office against the loss of a communications line, BellSouth central offices use redundant routing. This means that every central office is linked to the telephone network by two separate cables, or "channels," each entering the central office at a different location. If the primary cable is cut, communications traffic is automatically switched to the secondary channel. This switching is so fast—less than a hundredth of a second—that callers should never notice an interruption.

Protecting central offices

BellSouth has exemplary building standards for their central offices to be able to withstand hurricane force winds. Central offices house the switches which are critical to maintaining service. The switches also represent a substantial business operation expense. For example, a new switch at Shelby, North Carolina, replaced in 1995, cost $4.4 million. At this price, BellSouth's investment in protecting their central offices makes fiscal sense.

In addition to protecting the facilities, the central offices are also protected against interruptions in commercial electric power. In Wilmington, North Carolina, for example, a diesel generator, reserve fuel, and backup batteries are in place in each central office. The generator is activated by a technician on the approach of a major Atlantic storm.

Proven success: Hurricane Fran

During Hurricane Fran, mitigation measures such as retrofitted central offices, redundant routing, and underground fiber optic cables resulted in:

- *not one central office suffered a service interruption,*
- *continuous operation of BellSouth's primary network, and*
- *more than 90% of the customers never losing telephone service.*

On September 5, 1996, Hurricane Fran hit the North Carolina shoreline near Cape Fear with torrential rain and winds of up to 115 mph. Due to mitigation measures like retrofitting of facilities and redundant routing, not one central office suffered a service interruption, and BellSouth's primary network continued to operate throughout the storm.

Subscriber loop carriers (SLC) serve as communication hubs for local neighborhoods. The SLC's that lost commercial electric power automatically switched to battery power without dropping service. To keep the batteries charged until the commercial power was restored, BellSouth deployed some 600 mobile generators from its facilities throughout the southeast. Technicians worked around the clock, rotating the generators among hundreds of SLC's, keeping the batteries charged and the subscriber loops carriers operating.

Mitigation measures, such as those described above, resulted in more than 90% of BellSouth customers in Hurricane Fran's path never losing telephone service. For the 10% that did lose service, BellSouth's response plan swung into action immediately following the hurricane. Over 1,400 BellSouth employees were deployed into the region to repair the damaged poles and cables, reestablishing telephone service to approximately 95% of homes and businesses within ten days. BellSouth believes this impressive performance would not have been possible had mitigation measures not been implemented.

Community partner: BellSouth Pioneer volunteers

Less than 72 hours after Fran's impact, the BellSouth Pioneer Volunteers were on the way to help those in greatest need. The Pioneers delivered water and ice to families without electricity, and assisted at the local Red Cross Emergency Center. Pioneers also staffed the switchboard of a toll-free help-line for hurricane victims. The Pioneers' outstanding dedication and support during the crisis were praised by North Carolina Governor James B. Hunt and the State of North Carolina Emergency Management Office.

Conclusion

Although BellSouth's service area may experience more than its share of damaging storms, no region of the United States is free of natural hazards. Organizations dependent on voice and data networks can benefit from hazard mitigation measures like BellSouth's. For operators of large voice or data networks, measures such as buried cabling, redundant routing, optical fiber, battery back-up, and electrical generators can all be vital components of a comprehensive hazard mitigation program. Such mitigation measures help maximize reliability of service under all conditions, and minimize the costs of network repairs and lost revenues following a disaster.

Andritz, Inc.: Protecting Equipment and Inventory

Andritz, Inc. manufactures, at their Muncy, Pennsylvania, facilities, a variety of specialized capital equipment for the paper and feed industrial market worldwide. The facilities have been operating continuously for over 100 years on 40 acres near the Susquehanna River. Approximately 500 people are employed at the site, which covers 600,000 square feet of office and manufacturing facilities, and houses a $150 million annual operation.

The past economic success of the facilities has been largely due to its focus on making the most effective use of resources and personnel in order to improve the company's position in the world market.[5] Andritz turned to cost-effective mitigation measures to protect its valuable equipment and inventory at risk to flood damages due to the site's vulnerability to flooding.

The Muncy Creek flood threat

The Andritz site is partially in the 100-year floodplain[6] of the West Branch of the Susquehanna River. The Andritz facilities are also less than a mile from Muncy Creek, which feeds into the Susquehanna. Floodwaters, principally from the creek, have reached the facilities an average of once every 10 years.

In contrast with sites used primarily for office space, the principal flood threat to the Andritz manufacturing facilities is not to buildings or life safety. The greatest risk is damage to capital equipment and inventory. Flooded mechanical systems can rust, or become clogged by mud and debris. Electrical systems can short-circuit. Manufacturing molds and materials can be ruined by water.

The majority of the facilities' capital equipment ranges in value from $50,000 to $200,000. However, some pieces, like boring mills, cost in excess of $500,000. At any one time, the facilities contain completed and in-production inventory that sells for $50,000 to $500,000 a piece. With the high value of its capital equipment and inventory, floods can result in large economic losses rapidly.

Flood mitigation measures at Andritz

Andritz management and employees began developing a comprehensive flood mitigation and response program in the early 1970's. During this time, the company implemented dozens of engineering

[5] http://www.remstar.com/customer/profasb.html on 01/24/98
[6] A 100-year flood is a flood that has a 1% probability of being equaled or exceeded in any given year and is the basis for the regulatory requirements of the National Flood Insurance Program.

and architectural flood-proofing measures, representing many of the cost-effective options available to industries located in floodplains.

Relocating critical facilities

A complete relocation of the Andritz facilities proved impractical. However, the company was able to move critical systems, such as emergency lighting and electrical systems, fire sprinkler pumps, fuel storage, and HVAC systems out of the 100-year floodplain. To ensure supplies of electricity and water for post-flood clean-up activities, back-up propane generators and water pumps were also relocated out of the floodplain.

Modifying building architecture and systems

To protect facilities that could not be moved, the company designed a number of simple but effective architectural modifications. For example, many wood floors were replaced with concrete slab; electrical doors were retrofitted with manual back-up mechanisms; and doorways were widened to accommodate evacuation equipment.

In the 1980's, Andritz constructed major additions to vulnerable facilities including a metal foundry and an automated molding line. The expanded facilities were specifically designed to keep primary electrical systems well above the 100-year flood level: electrical control rooms were constructed on a mezzanine, and ground-floor electrical systems were installed four feet above the floor.

Expanded facilities were specifically designed to keep primary electrical systems well above the 100-year flood level: electrical control rooms were constructed on a mezzanine, and the ground-floor electrical systems were installed four feet above the floor.

Protecting the shop floor: "design-for-evacuation"

For much of the Andritz facilities, the most important protective measure is to quickly remove vulnerable machinery and materials from harm's way before floodwaters arrive. Andritz has engineered a variety of effective measures which speed the processes of disassembling, removing, and later reinstalling equipment on the shop floor. For example, "Quick-disconnect" fittings are installed on electrical, hydraulic, and plumbing lines.

"Quick-disconnect" fittings cost approximately $5.00 versus $3.00 for traditional wiring. With this inexpensive measure, capital equipment can be rapidly evacuated if flood waters threaten the facility. Additionally, after the flood, or flood threat, the "quick-disconnect" fittings lower the time required to resume normal operations.

Large machinery weighing hundreds of pounds must be rigged with chains or straps for removal with cranes or forklifts. To eliminate much of this rigging time during evacuation, engineers welded lugs and lifting bars directly onto the equipment. Similarly, inventory is now stored on pallets for quick removal by forklift, and large motor-generator sets are mounted on movable skids.

Limiting flood losses: proven success

The measures discussed above were largely implemented after Hurricane Agnes in 1972, and before Tropical Storm Eloise in 1975—two storms that caused similar levels of flooding. A comparison of the damages sustained before and after the mitigation measures were implemented reveals the cost-effectiveness of the Andritz program. The table below shows the lost revenues, physical damages, and emergency response costs of flooding from the two storms.

Table 1: Flood costs before and after mitigation measures (1979 dollars)

Costs	Before Mitigation Hurricane Agnes ('72)	After Mitigation Hurricane Eloise ('75)
Lost revenues	$2,147,566	$136,708
Physical damages	$744,280	$11,963
Emergency response	$491,843	$82,431
Total Costs	**$3,383,689**	**$231,102**

The company's mitigation measures implemented between 1972 and 1975 cost $30,000-$40,000 in 1979 dollars. These efforts contributed to over $3 million in cost savings from damages after Hurricane Eloise. While flood depths were similar during the two storms, losses were an order of magnitude lower in 1975. In fact, $2 million dollars were saved in lost revenues alone. According to Andritz, most of those savings reflect an improved ability to remove machinery quickly before a flood, and then rapidly return to normal operations after flood waters have subsided. Andritz considers its mitigation measures to be a wise investment that will yield benefits for decades to come.

Due to the implementation of mitigation measures, which cost between $30,000-$40,000, Andritz saved over $3 million after Hurricane Eloise.

These cost savings have led Andritz to improve and expand on the original flood mitigation measures since the 1970's. Andritz has annual reviews of their mitigation and response plans to monitor and improve the measures. Each January, prior to the annual flood threat season, the plan is reviewed by a group which includes many levels of staff, from the foremen to senior management. Based on this review process, the Facilities and Environmental Engineer updates and modifies the plan.

Conclusion: Flood mitigation lessons for manufacturing

Manufacturing firms vulnerable to flooding can benefit from the lessons learned at the Andritz facility in Muncy. Andritz found that even relatively modest investments in mitigation measures can pay off in real, bottom-line savings when disaster strikes. Each of the many measures—from quick-disconnects to elevated electrical systems—was based on repeated experience with flooding and careful study of flood-related challenges unique to the shop floor. In fact, the mitigation measures implemented at Andritz reflect the spectrum of engineering options available for companies in similar situations.

The Andritz experience demonstrates that for manufacturing facilities, flood mitigation measures reduce flood losses in three ways: first, by facilitating evacuation and other response measures; second, by reducing direct damages to capital equipment and inventory; and third, by reducing the time required to get the business up and running again after a flood.

Hewlett-Packard Company: Developing an Industrial Corporate Seismic Program

Hewlett-Packard (HP) is one of the world's largest and best known manufacturers of computers, semiconductors, and other high technology products. With over 300 facilities throughout the world, many are located in high and moderate seismic zones. Over one hundred HP buildings are located in the San Francisco Bay Area alone. Each one of these buildings plays a critical role in the development and manufacturing of their products. An earthquake-disabled building would mean lost development, lost production, and thus lost revenue.

With so many facilities at risk to earthquake damages, in 1988 HP began a five-year development effort for a massive seismic mitigation program. Multi-site organizations can learn from HP's success in addressing the unique engineering, logistical, and management challenges of hazard mitigation across state and national borders.

A unique challenge for seismic mitigation

Like most companies in earthquake-prone areas, HP needed a seismic mitigation program that would reduce the threat to life safety and business continuity. And like other high-tech companies, HP had tremendous investments in specialized manufacturing and research facilities—which often require greater earthquake protection than provided by local building codes.

HP's buildings were built nationwide, and in various countries, over a 40-year period, based on different building codes with a wide range of construction practices. As a result, HP's greatest challenge was to develop a consistent framework for evaluating hundreds of buildings, and prioritizing, budgeting, and implementing mitigation measures.

The HP seismic mitigation program

In 1988, HP embarked on a five-year comprehensive seismic mitigation program. HP's mitigation program was executed in four main phases:

Phase 1: Create worldwide seismic maps

Phase 2: Conduct preliminary evaluations of each HP facility

Phase 3: Perform detailed seismic evaluations of potentially vulnerable facilities

Phase 4: Retrofit or rehabilitate selected buildings

Concurrent with these four phases is a vital fifth component of HP's mitigation program: the development of consistent seismic evaluation and design standards for use in phases 2 through 4.

Phase 1: Create Worldwide Seismic Maps

With site locations all over the world, HP had to determine the relative seismicity of each site. For sites in the U.S., HP used the Uniform Building Code (UBC) seismic zone map.[7] For sites outside of the U.S., HP used published research to derive an "Equivalent UBC zone" for each site. Once the worldwide seismicity study was complete, all sites located in the equivalent of UBC Zone 2A or higher were earmarked for a preliminary evaluation of their seismic risk.

Phase 2: Preliminary Building Evaluations

In order to make funding decisions on seismic upgrades or more detailed building studies, HP needed to rank its buildings in order of life safety and business interruption risk. To this end, HP performed a preliminary, qualitative evaluation of each building. The evaluations used walk-through inspections, building plans, and published data to assemble the following types of information on each building:

- Regional geotechnical information
- Photographs of exterior elevations and interior conditions
- Architectural plans and sketches
- Checklists of critical structural and nonstructural elements in each typical building type[8]
- Field data (summarizing seismic resistance and expected performance of the building)

Phase 3: Perform Detailed Building Evaluations

The preliminary evaluation suggested which buildings were likely to be at risk and which required further study. The buildings were reexamined in detail to fully determine each building's deficiencies, retrofit options available to address the problems, and cost estimates for each option.

Phase 4: Implement Seismic Upgrades of Existing Buildings

Santa Clara, California One example of seismic upgrading of an existing building is HP's industrial building in Santa Clara, California. It was constructed in the 1960's with concrete frame. Though it ex-

[7] The UBC Zone Map divides the U.S. into earthquake hazard zones, ranging from zero to high seismicity, based on ground acceleration.
[8] Checklists from ATC-14, Evaluating the Seismic Resistance of Existing Buildings.

ceeded minimum seismic design requirements when it was built, it failed to meet current Zone 4 levels for reinforced concrete.

The required retrofit was an extensive system of steel frame bracing of the superstructure. It would have been prohibitively costly for HP to take the Santa Clara building completely out of service for the upgrade. So construction was carried out in phases, largely at night and on weekends, allowing HP to continue to use the building.

Corvallis, Oregon Another key HP site is currently preparing for a massive seismic retrofit—the HP manufacturing facilities in Corvallis, Oregon. The site's fourteen buildings are critical to production of HP's popular computer products such as inkjet printers. At Corvallis, HP is investing up to $46 million in structural upgrades alone; the need to maintain production levels during the upgrade process was factored into the cost estimate.

HP seismic guidelines for new construction

HP defined three levels (A, B, and C) of resistance to earthquake damage, or "seismic performance." The company designs its most critical industrial facilities to Level A, its highest seismic performance. For planning purposes, HP defines a Level A building as one that is repairable in less than two weeks after a major earthquake. Level B buildings are defined as repairable in 60 to 90 days. Level C buildings, typically housing office, sales and warehouse functions, are assumed to require more than 90 days to repair.

HP seismic guidelines for construction abroad

As with seismic retrofits, special consideration is sometimes required for new building construction outside of the U.S. Although some foreign countries have seismic standards and construction practices which equal or exceed those of the U.S., many do not.

HP's objective is to provide the same level of life-safety protection for building occupants as that offered by current U.S. codes. To come as close as possible to achieving this goal, it will be necessary to work closely with the architect and engineer of record and make adjustments to the building's design.

In the 1995 Kobe, Japan earthquake, HP's $58 million facility suffered only cosmetic nonstructural damages while surrounding buildings had severe damages or were totally destroyed.

Kobe, Japan A dramatic example is the HP office building constructed in Kobe, Japan in 1987. Seismic stiffening techniques, designed by HP architects and HP's engineering firm, augmented already stringent Japanese standards. Eight years later, the region was struck by a magnitude 6.9 earthquake—with the HP building near the epicenter. Yet while distant buildings were severely damaged or totally destroyed, the $58 million HP facility suffered only cosmetic, nonstructural damage. Not even a window was broken in the building.

HP seismic guidelines for nonstructural mitigation

HP recognized that earthquake risks posed by nonstructural elements (building contents and infrastructure) can be greatly reduced, and with relatively small efforts. HP developed detailed bracing and anchoring guidelines for non-structural elements. The guidelines include specific techniques for restraining many of the types of equipment frequently used in HP facilities.

For new construction, the guidelines supplement HP's A, B and C seismic levels. At existing HP facilities, the guidelines are used by facilities managers to guide internal HP staff or engineering contractors.

The guidelines are especially useful for demonstrating non-structural mitigation techniques to engineering contractors in areas where seismic bracing is often overlooked. For example, HP recently built a data center in Atlanta, Georgia, a region not known for its seismic activity. Contractors there used the HP guidelines to speed development of bracing and anchoring measures for critical mechanical and electrical systems.

Conclusion

For many private enterprises that have a few sites and a small number of buildings, the principal earthquake mitigation challenges are budgetary and engineering. But for large, high-tech multinationals with hundreds of sites and more seismically sensitive facilities, earthquake mitigation is a complex proposition. The sites must be evaluated, ranked, investigated, budgeted, and upgraded. Ideally, each phase should be executed consistently across buildings, sites and national borders, and despite widely varying building ages, construction practices, and zoning norms.

Three keys to success are thorough research; a systematic, global approach; and consistent standards—standards for evaluating seismic risk internationally, for evaluating individual building risk, for establishing the value of a structure to the company, and for prioritizing upgrade expenditures based on those risks and value. The example of Hewlett-Packard shows that while such an ambitious program may take years to realize, the challenges are not insurmountable. The reward is an increased ability to maintain business operations following an earthquake.

Checkers Drive-In Restaurants, Inc.: Withstanding Hurricane-Force Winds

Founded in 1986, Checkers Drive-In Restaurants, Inc. has grown to five hundred locations across the eastern and Midwest United States. Checkers' limited menu and double drive-through windows have created a niche in the fast food marketplace. Its back-to-basics approach has been key to its stores each averaging a million dollars in revenue per year.

Checkers has built storm resistance into the restaurants' modular design because many of the restaurants are in hurricane-prone southeastern states. The high building standards applied to the construction of the modular restaurants have resulted in reduced business disruption from natural hazards.

The Southeastern United States hurricane threat

The company's highest concentration of Checkers restaurants lies in three Southeastern states—Florida, Alabama, and Mississippi—where the restaurants are at risk to hurricane damages. From the turn of the century through 1994, 8 of the 15 most powerful hurricanes to hit the United States have made landfall in at least one of these 3 states. The most recent of these was Hurricane Andrew, which caused $25 billion in damages in 1992.

Restaurants designed to withstand hurricane force winds

Checkers restaurants are built to withstand high winds. Unlike most restaurant chains, Checkers has specially designed its modular restaurant buildings for centralized prefabrication and distribution from Clearwater, Florida, where the company is headquartered. The units are designed for transport over long distances with a minimum of wear and tear. In addition to transportability, the design provides a unique and important benefit: the ability to withstand hurricane force winds with little or no damage.

The sturdiness of the building design stems from the tubular steel used in the exterior walls and steel channels in the floors and roofs. The units exceed most building design criteria for similar structures, and all meet or exceed the local building codes in the communities where they are located. Yet, the modular units actually cost approximately 25 percent less to build than more traditional fast-food buildings.[9]

The benefits of such rugged, storm-resistant buildings are most apparent immediately following a disaster. Weeks before less well-constructed restaurants are operational, a Checkers restaurant can be up and running, employing its workers, and assisting the devastated community. These advantages were vividly demonstrated in the aftermath of Hurricane Andrew.

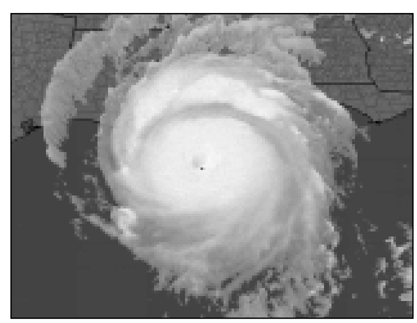
Hurricane Andrew versus Checkers

With winds of up to 140 mph, Hurricane Andrew, in 1992, was one of the costliest natural disasters ever experienced in the United States. Southern Florida was particularly hard hit, as the southernmost region of the peninsula was effectively destroyed. Even today—six years later—businesses continue to rebuild from Hurricane Andrew.

In contrast with thousands of businesses destroyed by Hurricane Andrew, Checkers' South Florida restaurants serve as an important lesson in the benefit of designing for natural hazard mitigation. Checkers' sixteen corporate-owned restaurants located in Dade County had no structural damages and were able to reopen as soon as electrical power was restored.[10] In 1992, corporate-owned restaurants generated over $85 million in sales revenues. Based on this sales figure, Checkers could have lost approximately $32,000 in sales revenue each day they were closed due to damages. High building standards significantly reduced lost revenue due to business disruption.

After Hurricane Andrew, all sixteen corporate-owned restaurants located in Dade County had no structural damage and were able to reopen as soon as electrical power was restored. Based on their 1992 sales revenues, Checkers could have lost approximately $32,000 in sales revenues each day if they had been closed due to damages.

Other Dade County fast food restaurants, not constructed to such high building standards, experienced an increased amount of damages and business disruption costs. For example, in the City of Perrine, Florida, the Checkers restaurants sustained only nonstructural damages. The national fast food chain restaurant, located next door, required major repairs before it could reopen, weeks after the Checkers restaurant.



Since Checkers Restaurants did not sustain major damages, they were able to provide a critical service to the devastated community. In both Homestead and Perrine, the Checkers restaurants provided a hamburger and beverage at no charge to the public for 3 days. The locations continued to feed the military at no charge for an additional week.

[9] Associated Press, "Sales Set to Sizzle," *Palm Beach Post*, 1 June 1993, sec B, p. 4.
[10] Telephone interview with Kris Wahl, Checkers Restaurants, January 1998.

The national fast food chain restaurant, located next door, required major repairs before it could reopen, weeks after the Checkers restaurant.

Conclusion

In the aftermath of Hurricane Andrew, Checkers reaffirmed that designing its restaurants to demanding specifications pays off in several tangible ways. First, almost immediately after the passage of Hurricane Andrew, Checkers was able to help feed the devastated community. Second, the cost of minor repairs and cleanup was significantly lower than the cost of major repairs—or replacement—of a traditional restaurant structure. Third, Checkers was able to return to normal operations within a fraction of the time required by similar restaurants.

Questar Corporation: Protecting Critical Information Systems

Questar Corporation is a $1.9 billion energy resources and service company headquartered in Salt Lake City, Utah. Through its subsidiaries, Questar's business spans a broad range of energy-related activities, including natural gas exploration, processing, and distribution. Natural gas produced and delivered by Questar is vital to business, industry, and thousands of households in Utah, Wyoming, and Idaho.

In the process of relocating and upgrading the Questar data processing center, the company developed an impressive example of hazard mitigation in the private sector. Questar's comprehensive hazard mitigation investments, and the company's rationale for undertaking them, signal a global trend: the increasingly critical role of information systems in the enterprise, and the need to protect those assets from natural hazards in order to guarantee business continuity.

The Wasatch Front earthquake

The Wasatch Front, a region of north-central Utah that includes Salt Lake City, is composed of numerous active faults that have repeatedly produced large earthquakes of magnitude 7 - 7.5. While the average time between large earthquakes on any one section of the Wasatch Front is on the order of one to two thousand years, the time between large events along the Front can be as short as a few hundred years. Destructive earthquakes of lesser magnitude may also occur with even greater frequency. In short, the region is vulnerable to earthquake hazards.

Protecting a natural gas network

In addition to key business applications, such as billing and internal communications, Questar's Business Continuity Center contains their backup gas control center. The gas control center allows Questar engineers to monitor gas flows, quality, and pipe condition, and regulate the delivery of natural gas across the pipeline network—routing gas from wells, through hundreds of miles of pipeline, around stuck valves or broken pipes if necessary, all the way to businesses and homes. The backup gas control center is critical to ensure continued operation of these functions in the event that an earthquake disrupts operation of the primary gas control center.

Mitigation measures

By the mid 1990's, Questar recognized that its existing data center could no longer afford vulnerability to earthquakes or other hazards. Questar believed that even the best disaster response and preparedness plan, on its own, would inevitably be too little, too late. In the event of a major earthquake, recovery was estimated to take 6 weeks. However, a strategic prevention approach would reduce the risk of deficiencies in accessibility, timeliness, communication and network recovery. So Questar decided to focus on preventing damage from natural hazards.

Building to a higher standard

The current Utah building code for seismic protection is in accord with Zone 3 standards of the Uniform Building Code.[11] Due to the importance of the existing data center, Questar management decided not to simply upgrade the facility, but to build a new one to a higher level of earthquake safety.

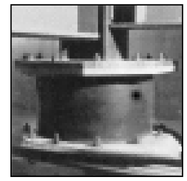
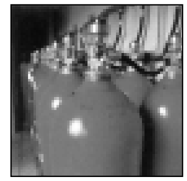
The completed 22,000 square feet, two-story complex now meets the Zone 4 "Essential Services" standards of the Uniform Building Code. These standards are designed to protect vital functions, such as emergency medical services, during a major earthquake. The standard is designed to allow so little damage that operations within the building may actually continue with minimal or no interruption when a major earthquake strikes.

In addition to Zone 4 building standards, Questar decided to incorporate the latest seismic mitigation technique: base isolation. Nine such isolators, or rubber-and-teflon pedestals, support the building superstructure. The isolators, in turn, are mounted on a massive footing—essentially a solid slab of 500 cubic yards of concrete. During an earthquake, the footing provides a stable base on shifting or liquefying soil.

Though relatively new, the technology has been proven in recent earthquakes in California and Japan. In 1995, near Kobe, Japan, a six-story, 500,000 square feet, seismically isolated building suffered no damage during a devastating magnitude 6.9 earthquake. The building, and a nearby building without isolators, were equipped with instruments that recorded the movement of the buildings. The instruments showed that the impact of ground movement on the building with base isolators was nine times less than on the building without them.

[11] See Uniform Building Code for more information about building standards.

Nonstructural mitigation measures


In addition to seismic isolation, building contents such as HVAC (heating, ventilation and air conditioning), other systems and equipment are seismically braced. This type of measure is critical: even in structurally undamaged buildings, many injuries and costly damages are caused by falling machinery and building heating and cooling systems.

Questar estimates that it cost $1 million to include the base isolation, structural reinforcement, and miscellaneous security features in its new facilities. The dollar value of the equipment, like computers and telecom equipment, protected by both the structural and nonstructural mitigation measures is over $8 million. This does not include the cost to replace or regenerate any lost data or files. Questar's investment in mitigation will pay for itself at least ten times over in the event of a major earthquake.

Intelligent fire protection

Fire is a major secondary earthquake danger. Questar equipped its Business Continuity Center with "smart" electronic fire suppression systems. In electronic equipment areas, a moisture-free, environmentally-friendly system can dispense a chemical fire suppressant, that won't damage equipment, in the precise location of a fire. In office areas, a sprinkler system is triggered only by actual fire—rather than smoke alone—to limit potential water damage.

Reliable computing

First, to ensure continuous protection of critical data, computers in the Business Continuity Center employ the highest level of redundancy available (known as "RAID Level 5") for hard drives and power supplies. Second, data is backed up daily on tape. Third, critical systems data are continually "mirrored" (duplicated via network connection) at another Questar site. And finally, if protective measures, redundancies, and back-ups should fail, Questar can load and run many of its critical applications at a leased "hot site" located outside of the earthquake risk area.

Reliable data communications

The Business Continuity Center is connected via high-speed fiber optic cable to two different commercial network operators, for both voice and data communications. If the primary network connection is damaged by an earthquake or other hazard, voice and data communications can be switched to the other network with minimal loss of data.

In the unlikely event that both network links are compromised by a major regional disaster, the Business Continuity Center is equipped with a wireless, digital microwave link to a remote Questar facility. Questar can route any of its data communications through this link to the remote site, where the data can be re-routed to operational land-line networks.

Reliable electrical power

Even if it were possible to eliminate every damage threat to the Business Continuity Center, without electrical power every computer would grind to a halt. To protect against power outages due to an earthquake, every Questar computing resource is connected to a system of batteries and line conditioners called an uninterruptible power supply, or “UPS.” When the electrical supply is interrupted, the UPS takes over instantaneously, ensuring continuous, filtered power. Since UPS batteries have a limited capacity, the Business Continuity Center is also equipped with a large diesel generator. The generator “spools up” in only twelve seconds—well before any UPS batteries would be exhausted—and can supply power for the computer equipment and selected outlets in the office space. A fuel reserve of 4,000 gallons permits continuous operation for up to 72 hours before refueling is necessary.

In the event of an earthquake, Questar's $1 million investment in mitigation measures for its facility would protect over $8 million in equipment alone. Questar's investment in mitigation has the potential of paying for itself ten times over.

Guarding against water and storm damage

Though the Business Continuity Center is not in a high-risk floodplain, moisture sensitive electronics must be protected against possible flooding due to torrential rainfall or local drainage failure. Questar’s equipment is protected by raised floors, and a network of water sensors.

Another storm hazard is lightning. If not protected, computers and electronic equipment could easily be damaged by the high-voltage pulse of a direct lightning strike. Questar built lightning rods and a grounding system into the roof perimeter of the Business Continuity Center, to short-circuit lightning into the ground.

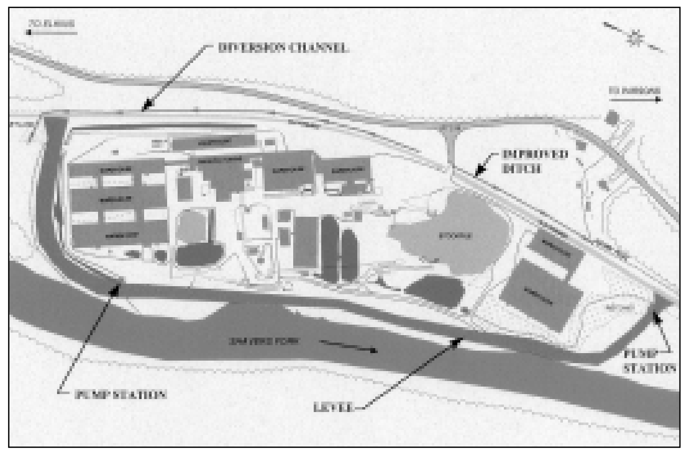
Conclusion

Businesses today rely increasingly on information systems for everything from accounting and order tracking to communications and mission-critical applications. An inevitable result of this digital revolution has been a shift in balance of costs and benefits for hazard mitigation. An information systems crisis that might have gone unnoticed beyond the computer room fifteen years ago might lead to a catastrophic business interruption today. To protect itself and its customers, Questar invested in a showcase of natural hazard mitigation measures. Questar’s efforts are so extensive that other firms, notably in banking and telecommunications, have leased space and data processing capacity in Questar’s Business Continuity Center to ensure their own business continuity.

Kingsford Manufacturing: Protecting Manufacturing Facilities

Two miles outside the town of Parsons in Tucker County, West Virginia, lies the Kingsford Manufacturing Company's charcoal production plant. The plant, the most productive of five such facilities throughout North America, produces 100,000 tons of Kingsford brand charcoal annually. Built in 1958, the Kingsford plant compound is located in a scenic valley next to the Shaver's Fork River on the only flat terrain in the area. The fifty-acre site encompasses 300,000 square feet of office, manufacturing, and warehouse building space. It employs over 100 people from the community.

The Kingsford plant is an essential member of its local community, contributing over $8.5 million to the economy in direct impact including payroll, taxes, and purchases of supplies, utilities, and raw materials from local lumber mills. Additionally, the Kingsford plant's total economic impact on this community is estimated annually at $23 million. In order to continue production operations, and to support the local community, the Kingsford plant constructed an extensive mitigation system to address its flood hazard.[12]



The flood hazard

Kingsford's manufacturing plant and most of its warehouses are located in Shaver's Fork River's 100-year floodplain. This means that there is a 1 percent likelihood each year that the plant will experience two- to six-foot flooding across the compound.[13] One such flood occurred in 1985, when floodwaters of up to seven feet caused $11 million in damages. The plant was completely shut down for two months and was not in full production for six months.

More frequent floods, not as deep as 100-year floods, can still be very costly. Floodwaters have invaded the plant four times in the last twelve years alone, costing the company millions of dollars in damaged equipment and finished product, and lost production time. The table below shows highest flood depths, plant downtime, and damages to the company from the last three major floods at the plant.

[12] Kingsford Manufacturing, Mitigation Survey to AIS, Inc., November 1997.
[13] Lennon, Smith, Souleret Engineering, Inc.

Recent floods and damages at Kingsford Manufacturing

Flood Date	Flood Depth	Plant Downtime	Damages
November 1985	7ft*	2 months	$11 million
January 1996	3ft	1 week	$3 million
May 1996	2ft	36 hours	$1 million

*Greater than 100-year flood

The flood mitigation program

To protect its inventory and business operations, Kingsford hired two engineering firms in 1996 to help determine the best approach for flood-proofing the manufacturing plant compound. The firms proposed several options, including relocating the plant away from the river, constructing a flood wall, "hardening" equipment against floodwaters, elevating the product stored in warehouses, and building a levee. Kingsford selected the most feasible and cost-effective project whose primary elements included a levee to surround three sides of the plant, and supporting measures such as flood diversion structures and pumping stations.

Diversion swales

To help divert floodwaters away from the compound, large grass-covered gullies, called diversion swales, are incorporated into the landscaping at the higher, eastern end of the compound, and planted with grass to help reduce soil erosion during non-flood conditions.

A 3,400-foot long levee

Floodwaters that overwhelm the swales will be met by the central element of Kingsford's flood mitigation plan: a massive earthen levee bordering the north, east, and south sides of the site. The levee is 3,400 feet long and six to twelve feet high, and is constructed from cohesive clay and silt soils tested for their impermeability to water. To provide an even greater level of protection, the height of the levee includes an additional foot of reserve, or freeboard, above flood depths of a 100-year flood event.

Cut-off wall and toe drain

Geotechnical analysis revealed that the Kingsford site rests on permeable sand and gravel. Therefore, floodwaters held back by the levee could seep under the levee and "percolate" up into the compound. To prevent seepage under the levee, Kingsford is constructing a cut-off wall, an impermeable, two-foot thick underground barrier, extending to bedrock along the length of the levee. An underground drain will collect any accumulation of rain and groundwater within this barrier and direct it out to the Shaver's Fork River.

Pumping stations within the facility

To remove floodwaters that enter the compound from torrential rains or by floodwaters high enough to crest the levee, two pumping stations will be installed at the lower elevations within the compound. Each of the stations can pump ten thousand gallons of water out of the compound per minute.

Mitigation benefits and costs

Kingsford's flood protection system was intended to provide numerous cost savings benefits:

- protect inventory
- protect against business interruption
- protect against an estimated $3.9 million damage loss
- reduce flood insurance deductible
- enhance insurance coverage
- protect against uninsurable risk of loss of business due to loss of product

Most importantly, Kingsford's manufacturing operations will be protected against costly business interruption due to flooding. The project is supported by the company underwriting Kingsford's flood insurance policy as well as the State of West Virginia. For a project cost of $2.85 million, Kingsford may save an estimated $4 million in product and equipment damages from a 100-year flood.

Conclusion

With reduced insurance costs and quantifiable reductions in potential flood damages, Kingsford's flood control project is compelling evidence that flood mitigation investments can be cost-effective even in highly flood-prone areas. Additionally, Kingsford mitigation actions to preserve the economic viability of the plant assures local West Virginians that this important member of the community will contribute to the local economy for years to come.

Seafirst - Bank of America:
Comprehensive Approach to Building a Disaster Resistant Business

Seafirst Bank, a division of Bank of America NT&SA, today operates the largest consumer banking network in Washington State, and is one of the State's leading business and commercial real estate lenders. More than one million customers rely on Seafirst for essential banking services, from households to businesses, to city and State government. Thousands of Seafirst employees and other tenants work in Seafirst's high-rise buildings in downtown Seattle. Seafirst is the State of Washington's largest consumer banking network and leading business and real estate lender. As a large employer and banker to families, businesses and government, it is critically important that Seafirst be up and running as quickly as possible following a major disaster.

To protect their employees, tenants, and business operations, Seafirst has developed a comprehensive approach for reducing damages and business disruption, which includes mitigation measures such as non-structural reinforcement and redundant information systems. The Seafirst program represents an excellent model for all enterprises vulnerable to business interruptions from earthquakes.

Seattle area's earthquake hazard

Though wind storms and flooding have caused record damages in recent years, the catastrophic natural hazard threat to the area is from earthquakes. Experts believe that the region is due for a large earthquake. Researchers at the University of Washington estimate, for example, that if the two plates of the Cascadia Subduction Zone off the Washington coast were to slip, the result could be an earthquake with as high a magnitude as 9.0.

Historically, the Seattle area has experienced major earthquakes approximately every 30 years. An earthquake of magnitude 6.5 on the Richter scale shook the area south of the Sea-Tac airport in 1965—just over thirty years ago. Therefore, Seattle may well experience another major earthquake in the near future. Even more alarming, researchers recently discovered a shallow fault directly beneath the city. According to the University of Washington, this fault could generate a magnitude 7.0 earthquake, claiming hundreds of lives and causing millions of dollars in damage.

Mitigation measures

The essential foundation of Seafirst's mitigation and preparedness measures is the use of strong seismic building codes. Seafirst's high-rise buildings were built according to seismic building codes designed to prevent catastrophic building failure caused by ground shaking. To provide additional protection, Seafirst management implemented safety measures for its crucial information systems, and initiated an ongoing non-structural hazard mitigation program. Seafirst Bank has established a mitigation goal of life safety for all bank areas and a goal of operational continuity in selected spaces considered critical to business operations.[14]

Safeguarding information systems

After life safety concerns, the greatest threat to Seafirst's business operations is damage to the bank's vital information systems and account data. Like all financial institutions, Seafirst depends on its extensive data processing systems for daily operations.

In the event of an earthquake, Seafirst Bank stands to save a significant amount of computer replacement and information restoration costs. The cost to secure a computer is about $17.00. Replacing a computer and software could cost as much as $3,000. Additional costs would be incurred to recreate the data.

Seafirst Bank has addressed the issues of vital records as thoroughly as possible to protect the bank's assets, employees and stockholders. To safeguard critical data, Seafirst performs daily data back-ups of mainframes, file servers, and workstations. Seafirst back-up media—like all vital records at Seafirst—are stored in distant secure facilities, well beyond the range of any disaster threat to Seattle. Vital records, data, and applications can, in the event of a crisis, be loaded on computers at a remote back-up computer facility ("hot site") maintained for Seafirst. These provisions enable Seafirst's multi-state operations to continue even if a disaster interrupts or disables Seafirst's Seattle facilities. Only by having the records needed to resume business functions will Seafirst be able to survive a major disaster and continue doing business.[15]

Anchoring building contents & infrastructure

Even in a structurally sound building, one of the most serious dangers during an earthquake is posed by the contents of the building. Lighting and ductwork can fall from ceilings, and shelving and office machines can tumble from walls and desks, causing severe injuries and costly damages. The non-structural program objectives are simple:

[14] Seafirst Bank, "Seafirst Bank Managers Guide to the Reduction of Nonstructural Earthquake Hazards," 1997.
[15] Seafirst Bank, "Seafirst Bank Vital Records Program," November 17, 1997.

- safeguard the people by removing exit barriers and reducing hazards from falling objects,
- reduce the risk to equipment susceptible to seismic effects, and
- prepare the infrastructure to reestablish "business as usual" as quickly and effectively as possible.[16]

The goal of Seafirst's non-structural mitigation measures is resumption of business operations "in-place". Transferring business operations to alternative facilities slows the resumption of services to customers and creates further disruption to employees who may have disaster damage in their homes. Non-structural mitigation measures are a key means of quickly restoring normalcy after a disaster.

To minimize the non-structural danger, an engineering consultant helped Seafirst identify 32 categories of potential risks and determined how best to secure each of them. Seafirst engineered and installed a securing mechanism for each category of potential risk. When this phase of the mitigation program was complete, ceiling tiles, lights, and plumbing systems were anchored to prevent them from falling. Computers, printers, copiers and other office equipment were braced and secured. Braces were also added under raised floors. Ventilation, heating, and other building system components were anchored. Even items such as water coolers and fire extinguishers were more securely fastened.

Seafirst's $1 million investment in non-structural mitigation will save an estimated $30 million in replacement costs, not including installation.

Seafirst's non-structural mitigation efforts are a good example of cost-effective hazard mitigation. Anchoring building contents reduces property damage and helps protect people from falling debris, at a small fraction of the replacement cost of those contents. For example, the cost to secure a computer was $17.00. Replacing the computer and software could be as much as $3,000. Additional costs would also be incurred to recreate the datafiles and documents. The value of this information is significantly more than the cost of the machine. In the event of an earthquake, Seafirst stands to save a significant amount of replacement and information restoration costs.

At less than $1 million, Seafirst's non-structural mitigation expense for its administrative building represents only 4% to 5% of the estimated $20 million replacement cost—not including installation. For its branches, Seafirst estimates a cost under $4,000 per branch. The replacement cost for the equipment is over $79,000. By implementing

[16] Compass Management and Leasing, Inc., report to Seafirst Bank on non-structural mitigation measures, November, 1997.

non-structural mitigation measures in 400 branches, Seafirst would save over $30 million in replacement costs.

Preparedness and Response Training

Seafirst's extensive preparedness and life safety training programs complement the bank's structural and non-structural mitigation measures. For example, Seafirst has produced educational materials and an award-winning instructional video that prepare employees for a natural disaster at home or on the job. Seafirst's training programs will reduce costs after a disaster by increasing the employees' ability to return to work due to reduced damages in their homes, and through the increased rate of resumption of business operations.

To promote preparedness by their individual employees, Seafirst staff are encouraged to keep a small backpack at work containing several days' food and medical supplies. The backpacks and some of the preparedness materials have been made available at cost from Seafirst's company store. Additionally, it gives "disaster packs" to employees as product awards.

Seafirst also trains specialized employee-volunteer response teams composed of crisis managers, medical responders, and a search-and-rescue teams. Using converted warehouse space and excess furniture and equipment, Seafirst has created its own realistic post-disaster destruction scene as a training facility. The company offers Seattle's police, fire, bomb squads, and search-and-rescue teams use of the training facility to practice their disaster-response skills. The resulting exchange benefits both Seafirst and local emergency responders, and contributes a useful resource to the Seattle community at large.

The ability of the community to respond to disaster and resume normal operations directly impacts Seafirst's ability to resume business. Therefore, Seafirst has developed innovative means of assisting its community. For example, Seafirst will provide approximately 10,000 square feet of office space to serve as a back-up Police Command Center for the City.

Conclusion

In the aftermath of a major earthquake, thousands of affected residents, businesses, and government agencies would urgently need to access funds deposited with Seafirst. For example, to rebuild the region, State and local agencies may need to hire and pay contractors. Businesses would need to disburse payroll checks. And families would need to withdraw funds for food, supplies, medical treatment, and home repairs. Clearly, the shorter the business interruption at Seafirst, the faster the local economy can return to normal.

Despite Seafirst's progress to date, their program is far from static. The program to anchor building contents is ongoing in several Seafirst buildings. Additional improvements include increased use of automatic gas shut-off devices, which are triggered by low-level or precursor earthquakes.

Seafirst's commitment to its program is highly regarded by the emergency response and business communities. For example, the Boeing Company uses some of Seafirst's earthquake preparedness materials to educate its employees, and other companies have expressed interest in learning from Seafirst's efforts. The Spokane fire department even uses and disseminates Seafirst's educational materials. The bank's northwest earthquake preparedness video is widely used by other corporations, and State and local emergency response agencies for public education.

The attention generated by Seafirst's program is not surprising. From anchoring potentially dangerous building contents and safeguarding data processing capabilities, to realistic search-and-rescue and life-safety training, the Seafirst Bank emergency management program is an excellent example of comprehensive hazard mitigation and contingency planning. Such a mitigation program would be valuable to any company seeking to ensure employee safety and business continuity.

General Electric Corporation Aircraft Engines & Nuclear Energy:
Comprehensive Hurricane Mitigation

General Electric Corporation (GE) is well known for its consumer appliances, but the company also is one of the largest manufacturers of aircraft engines and nuclear components. Near Wilmington, North Carolina, the GE Aircraft Engine and Nuclear Energy business units conduct manufacturing operations on a shared, 1,650-acre site. The jet engine and reactor components produced there make the site a critical one for GE and its customers; and with three thousand employees and contractors, the site is also one of the most important employers in the area.

To protect these employees, and to ensure the facilities' ability to maintain operations following a natural disaster, GE has implemented extensive storm mitigation measures over the last thirty years. GE's mitigation measures at the Wilmington site reflect issues common to large industrial facilities in hurricane-prone areas. One example is the company's enormous investment in specialized equipment, which may be vulnerable to storm damage. Another example is the facility's requirement of virtually uninterrupted electrical power and communications.

The North Carolina hurricane threat

Less than twenty miles from the Atlantic coast, GE's Wilmington site is at risk to damages from windstorms or hurricanes. In 1996, for example, the facility was hit by both Hurricanes Fran and Bertha. The high winds and flooding from such storms have presented a number of challenges for GE over the years.

Left unreinforced, roofs and walls could be stripped from the corrugated metal buildings by hurricane winds. Unless designed for heavy rain conditions, waste processing lagoons could overflow and threaten the environment. The extensive electrical, telephone, computer, and nuclear safety systems on the site are potentially vulnerable to storm damage as well, and are vital to the safety of employees and the community at large. As a result, the company's natural hazard mitigation measures are wide-ranging and comprehensive.

GE's mitigation program

GE's many mitigation measures—ranging from storm-resistant architectural design to redundant communication systems—have evolved through years of experience, experimentation, and changing building codes.

Building and storage area retrofits

Based on storm experience since the facility was constructed, the three large primary buildings were retrofitted for improved storm resistance. For example, GE doubled the number of fasteners attaching the metal siding to the buildings' steel frames. The buildings' corner attachment points and roof perimeters were reinforced. Where possible, protruding fixtures on the roofs were removed, and others, such as exhaust stacks, were tied down to reduce their vulnerability in high winds.

BEFORE **AFTER**

GE's Emergency Control Center has also been hardened and reinforced against storm damage, and equipped with emergency power, telephones and radios.

Outdoor equipment storage facilities at the site have proven particularly vulnerable to hurricane damage; metal containers and machinery blown by hurricane-force winds have the potential of damaging nearby structures. As a result, several outdoor storage areas have been dismantled. Equipment has been moved indoors where possible, and outdoor equipment is now secured with tie-downs on the approach of a storm.

Ensuring power and water supplies

Uninterrupted supplies of water and electricity are critical to safety at the Wilmington site. To maintain constant access to water, GE pumps its own water from wells drilled at the site. GE worked with Carolina Power & Light to dedicate an electrical power substation solely to the GE compound. Should the substation be disabled by a natural disaster, GE can rely on its three large diesel and gasoline generators to deliver more than a megawatt of power to critical systems.

Backup communications

Loss of communications can be as potentially costly as the direct physical damages of a disaster, particularly for large organizations like GE. To maintain communications at the Wilmington facilities, GE has redundant connections to the local phone system, a back-up PBX system, and emergency cellular phones. Additionally, the site uses a 800MHz Trunking Radio system with a 12 miles effective radius that also is compatible with local government radios.

Protecting computing resources

On the approach of a storm, mainframe data are backed up and the systems are shut down to protect them. In addition to extensive data back-up facilities for information systems, GE is evaluating the facilities that house its mainframe and computing resources for susceptibility to storm damage and water intrusion, so that these buildings and rooms can be reinforced if needed.

Comprehensive emergency planning

Natural hazard mitigation measures are one important component of GE's overall emergency management program. Like the mitigation measures, other important elements of the program, such as extensive preparedness and response measures, are also designed to reduce the potential costs—in lives and dollars—of natural hazard damages.

GE's Emergency Control Center manages the hazard mitigation, response and recovery activities at the Wilmington facilities. Response plans, responsibilities, and checklists are maintained and continually improved by the staff. Even if a natural hazard has forced the evacuation of employees, teams of volunteers remain at the facilities 24 hours a day to implement the response and recovery plans.

Reciprocal assistance

GE participates in reciprocal assistance agreements—both internal and external to GE—to pick up where mitigation leaves off. One such effort is an informal organization of hazard mitigation professionals from GE and other local industry. The group meets throughout the year to exchange emergency management information and experience. Members of the group benefit from resource pooling and sharing, cross-training and co-training, and mutual aid in the event of a disaster.

GE structures and facilities suffered only minor storm damage - despite the fact that both 1996 hurricanes were "direct hits" on Wilmington.

GE's site radio system is compatible with the county's emergency services system. Each have agreements to use allotted talk groups in each other's systems as backup communication in case of system loss.

Another example of reciprocal assistance comes from within GE. The company has instituted reciprocal supply and aid agreements between the Wilmington facility and another GE facility in Greenville, South Carolina.

Mitigation benefits

Today, GE's mitigation measures show the benefits of that experience. During Hurricanes Bertha and Fran in 1996, for example, when much of the region lost electricity and phone service, the GE site experienced no communications or power outages at all. GE structures and facilities suffered only minor storm damage—despite the fact that both hurricanes were "direct hits" on Wilmington.

Helping employees and the local community

GE actively helps its employees and the community to recover from disasters. For example, GE provides non-repayable grants to employees for repairs, food, and other disaster-recovery necessities not covered by insurance. And following Hurricane Bertha, "Elfuns" (a public service association composed of GE employees) from GE's Evandale, Ohio aircraft facility traveled to Wilmington to deliver supplies and volunteer assistance to the community.

Conclusion: GE's lessons in mitigation development

The history of hazard mitigation at GE's Wilmington facility provides at least three important lessons. First, because GE (like every large industrial organization) is unique and complex, its hazard mitigation program should be considered a long-term, evolutionary process, rather than a single, fixed solution. Second, no one mitigation measure is central. GE's mitigation program consists of many measures, large and small, which together protect GE's business, employees, the local community, and the environment.

Third, GE's efforts provide an important insight into how large corporate mitigation measures are developed. The company drew upon its own experience with hurricanes, but it also borrowed ideas freely from outside the company. Some of these ideas came from other industrial corporations, from GE's vendors, or from insurers. Others came from collaboration with municipal, corporate and community organizations.

GE believes that looking to expertise outside the organization, along with the constant evolution of its mitigation measures, has been key to reducing storm damage costs and life safety threats at the Wilmington, North Carolina facility.

AutoZone, Inc.: Earthquake Mitigation for the Corporate Headquarters Building

AutoZone opened its first auto parts and accessories store in Forrest City, Arkansas, on July 4, 1979. Less than twenty years later, the company is one of the country's leading auto parts retailers with almost 30,000 employees nationwide. AutoZone owns and operates every one of its 1,936 stores, and over 300 new stores are opened each year.

To support its extensive retail operation, AutoZone constructed a new eight-story Store Support Center in downtown Memphis, Tennessee. The Center serves as the hub of a large computer and communications network that continuously exchanges inventory, sales, and accounting data with every AutoZone store via two-way satellite link. To protect its business operations against the threat of an earthquake, AutoZone incorporated state-of-the-art seismic mitigation into the design of its new headquarters.

The New Madrid seismic zone

The most powerful earthquake on record in the continental United States occurred not in the Pacific states, but in the "New Madrid Seismic Zone." The zone is comprised of a series of earthquake faults stretching from Southern Illinois through Western Tennessee and into Eastern Arkansas. The record-setting earthquake—actually a series of three major earthquakes—occurred over a three-month period in 1811 and 1812. Estimated at greater than magnitude 8.0 on the ichter scale, the shocks were reportedly felt as far away as Boston and Washington, DC.

The New Madrid region remains seismically active, and AutoZone's Memphis headquarters lie within it. Although the probability of an earthquake as large as the 1811 quake is relatively low—roughly 3% to 4% within the next 50 years—somewhat smaller yet highly destructive earthquakes of over magnitude 7.0 are believed to occur in the region every 250-500 years. This translates to a 5% to 19% chance that a magnitude 7.0 quake will strike within the next fifteen years.[17] It is estimated that such an earthquake would destroy or severely damage buildings that do not have seismic protection built into

[17] Center for Earthquake Research and Information (CERI) at University of Memphis, Tennessee.

them. The result would be countless lives lost and billions of dollars in damage throughout much of the Central and Eastern United States.

Proven earthquake mitigation

Every AutoZone store depends on the Store Support Center for the data and communications essential to day-to-day operations. It is critical, therefore, that the headquarters building remain operational in the event of an earthquake. A single day of down-time could result in millions of dollars in business interruption costs. This concern led AutoZone management to invest in earthquake mitigation measures.

Beyond local building codes: a base-isolation system

In AutoZone's previous headquarters building, the company had put in place such measures as tying down computer systems, bolting filing cabinets to walls, and bracing ceiling and lighting systems. Although important for life safety and property protection, these non-structural measures were viewed as a short-term solution. As the company continued to grow, so did its requirement for larger, safer facilities. Motivated by the devastation of the 1989 Loma Prieta earthquake in California and the necessity to protect the company's critical information systems, AutoZone's then current Chief Executive Officer J.R. "Pitt" Hyde[18] decided to make AutoZone's new building as earthquake resistant as possible.

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In 1992, AutoZone's engineering team developed three options (see table) for construction of an eight-story earthquake resistant office building to house more than 900 employees and AutoZone's information and communications systems. Each of the three proposals met or exceeded local building codes.

AutoZone Headquarters Building Options

Headquarters Construction Option	Cost
1) Building constructed to Zone 2 earthquake protection as required by local building codes	Base Building Cost
2) Building constructed to Zone 3 enhanced earthquake protection, beyond minimum building code requirements	Base + $800,000
3) Building constructed to Zone 3 with base isolation, a higher level of earthquake protection protection	Base + $950,000

[18] Retired in 1997

Base isolation is a construction technique that dampens the impact of horizontal ground movement on a building. The isolators consist of an array of flexible disks (made of rubber, steel, and lead) installed in the foundation of the building. Because base isolators greatly reduce the swaying of a building during an earthquake, they eliminate much of the need for costly reinforcements to concrete walls, windows, and building systems, as required under Option Two. As a result, the base isolation option costs only $150,000 more than the total cost of Option Two.

AutoZone felt that because the company's survivability depended on the Store's Support Center, located at AutoZone's headquarters, greater earthquake protection than the level offered by Option One was warranted. Thus, the third option was selected for the additional, proven protection of base isolation at minimal additional cost.[19] In October 1995, AutoZone moved its headquarters into the new building.

Emergency back-up for power and computer systems

AutoZone has installed backup systems to help protect headquarters operations in the aftermath of an earthquake or any other major disaster. For example, the company installed emergency diesel generators to power essential information systems when commercial power is interrupted. As a further safeguard against losing computer resources, AutoZone maintains a "hot site" of computer facilities outside of the earthquake zone. Company data is backed up within the headquarters building each night, and is backed up to the hot site every three days.

Proven benefits with marginal additional cost

AutoZone's mitigation measures translate into lives saved and millions of dollars in avoided business-interruption costs in the event of an earthquake. The electrical power backup can benefit the company in any hazard that threatens the supply of commercial power—from ice and wind storms to power grid overloads. The company's information and power backup systems together reduce the chance that communications and support for its thousands of stores will be interrupted.

AutoZone's base-isolated headquarters protects both operations and life safety against the threat of a major earthquake. The potential benefits of base isolation are dramatic: horizontal ground movement, transmitted to the building through the base isolators, is dampened by a factor of five to ten. So a magnitude 8.0 earthquake would be felt as a much less damaging magnitude 5.5 earthquake.

Upgrading from a zone 2 to a zone 3 building standard cost only an additional $800,000. Building a base isolation headquarters cost an additional $150,000. The combined $950,000 investment in upgrading the resiliency of the facility, represents only a 5% increase in the cost of construction.

[19] Although base isolation can be added to a building's foundation after construction, it is much less costly to incorporate base isolation into the design of a new building.

A compelling demonstration of base isolation's effectiveness (and one of AutoZone's primary reasons for choosing base isolation) was provided by two buildings on the Cal Tech campus during the 1994 Northridge earthquake. One of the buildings was constructed with base isolation, the other without it. The 9-story base-isolated building received only minor, non-structural damage in the magnitude 6.8 quake. But a similar building nearby, without base isolation, sustained $250 million in major structural and non-structural damages.

Perhaps the most compelling argument for base isolation was its minimal additional cost. Incorporating base isolation into the new building cost only $150,000 more than the cost of building to the next lower standard. Considering that millions of dollars in revenue could be lost for even a day of downtime at headquarters, the value of long-term protection for AutoZone's national operations far outweighed the additional, initial cost of base isolation.

A public-private research effort

AutoZone's story also offers an excellent example of a public-private partnership at work. AutoZone and the University of Memphis Center for Earthquake Research and Information (CERI) have agreed to use the headquarters building in an ongoing, long-term research effort. With funding from CERI and the United States Geological Survey, AutoZone has installed 21 motion sensors throughout the building. Motion readings from the sensors are continuously transmitted to an on-site computer, which CERI can access via modem.

The New Madrid fault system is active and averages more than 200 earthquakes per year—eight to ten of which are large enough to be felt. The data collected from the AutoZone building helps researchers better understand the effects of earthquakes on base-isolated buildings, and will be useful in developing safer building standards for future generations.

Conclusion

AutoZone's mitigation program in Memphis underscores three important lessons for American private enterprise: First, significant earthquake mitigation is not just for businesses located in Western states. Second, companies should not limit their building designs to the minimum standards required by local codes. If the facility is critical for maintaining corporation-wide operations, the cost of stronger mitigation protection is a good investment. Finally, even the most advanced protective measures, such as base isolation, can be cost-effective by a large margin—especially when incorporated in new construction.

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