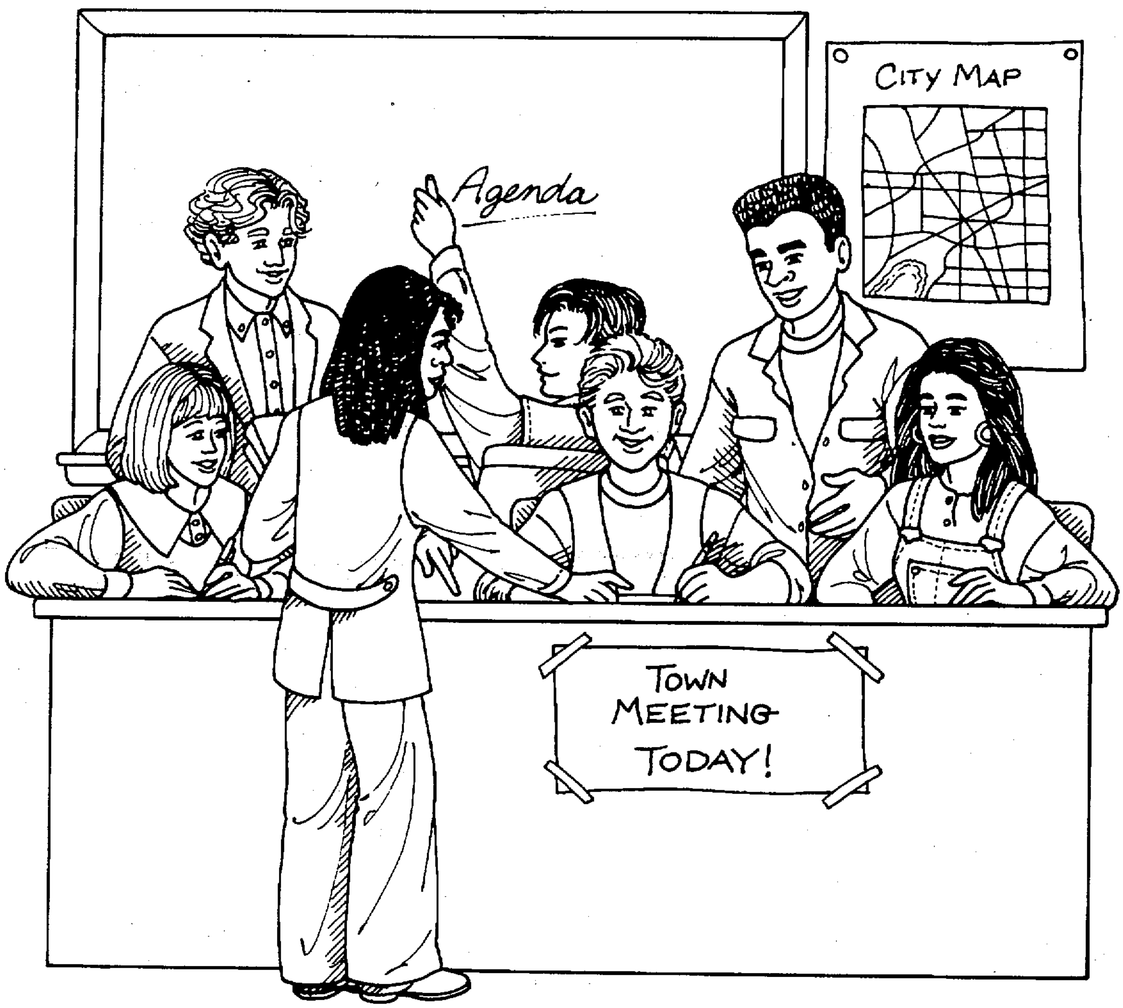
UNIT SIX



Now You Know It, Can You Show It?

The concluding unit of this curriculum offers a variety of summing-up and assessment activities. Students will feel pride in their accomplishments after a pair of high-pressure simulations, a fast-paced quiz game, and finally, a reprise of the writing activity in Unit 1. The appendix to this unit provides materials from an intensive, communitywide simulation developed by Vermont teacher Sean Cox and adapted with his permission. You can use these materials to enrich your students' experience of Lesson 6.2.

Students who have developed relationships with people responsible for emergency preparedness will particularly enjoy the opportunity to role-play in the first two lessons. In the first they will enact a meeting of a crisis team charged with developing a comprehensive local earthquake preparedness plan. In the second, Earthquake Simulation, they will put that plan into practice.

How much your students and your community benefit from Lesson 2, in particular, depends on how much you and they have invested in the curriculum up to this point. With the full involvement of community disaster officials and at a locale outside the school, this activity can be incredibly realistic and dramatic, as the experience of Sean Cox and his community makes clear.

After the excitement of Lesson 2, students will welcome the purely intellectual stimulation of Lesson 3, Test Your E.Q. I.Q. The questions are designed to test attitudes as well as information, and to reinforce knowledge by repetition.

Both you and your students will be pleased to see how much information they can add to their Unit 1 compositions in the final postassessment activity. This process reinforces essential writing and thinking skills.

Now that students have completed this series of lessons, encourage them to continue to read and write about earthquakes and disaster preparedness. Some of the topics that have been introduced in these units may lead to science projects, college majors in related topics, and future careers. The information students have gained may even save their lives.

6.1

Preparing for the Worst:
A Simulation

RATIONALE

When natural disasters occur, many communities are totally unprepared because they lack a comprehensive emergency management program. Coordinated planning is essential if the stricken community is to return to a normal state of affairs.

FOCUS QUESTION

What kinds of plans need to be in place to serve a community in the event of a natural disaster?

OBJECTIVES

Students will:

1. Recognize the importance of advance planning for a community's emergency response.

2. Simulate the development of a community emergency plan for preparing for, responding to, and recovering from a natural disaster.

MATERIALS

- Transparency made from Master 6.1a, Edenton Map and Profile
- Transparency made from back of Master 6.1a, Edenton Map and Profile
- Overhead projector
- Student copies of Master 6.1a, Edenton Map and Profile (2 sides)
- Master 1.3a, Preparedness People (from Unit 1)
- Master 6.1b, Planning Roles (*optional*, for reference only)
- Self-adhesive name tags, one for each student
- Transparency made from Master 6.1c, Phases of an Effective Management Plan
- Transparency markers in four colors

PROCEDURE

A. Introduction

Begin by asking students what they would do if an earthquake struck the area where their school is located. Help them to recognize that the most important immediate response is not to panic and to seek cover as quickly as possible. The most available cover in the classroom is the protection offered by the desks and tables the students are using, so "drop, cover, and hold" is the first response. If you have not done so recently, conduct a drop-and-cover drill now, using the instructions in Unit 5, Lesson 2.

Now expand the discussion to determine what students think would happen in their community if the earthquake was powerful enough to cause both loss of life and major property damage.

- How would the community respond?
- Who would be in charge of managing the rescue operation?
- Who would be in charge of long-term recovery?
- What plans are already in place to assure that the emergency would be responsibly managed?

B. Lesson Development

1. Explain the purpose of the simulation and tell students that they will be playing the roles of community leaders charged with developing an outline for emergency management in the event of a disaster resulting from a natural or human-made hazard. They are meeting to develop a system to manage the effects of an emergency, preserve life and minimize damage, provide necessary assistance, and establish a recovery system in order to return the city to its normal state of affairs as quickly as possible. Their plan must define clearly who does what, when, where, and in what order to deal with the community crisis.

Each student will adopt the role that she or he began learning about in Lesson 3 of Unit 1. For this activity, however, they are citizens of Edenton, a mid-size city located in an area of moderate risk for earthquake activity. In the late summer and fall, brush and forest fires also pose a threat to the community. Other disaster situations could develop from terrorism, civil disorder, a major transportation accident like a bus or train wreck, or an accident involving the release of hazardous materials. When the emergency exceeds the local government's capability to respond, city officials may also call on state and federal governments for assistance.

2. Project the back of Master 6.1a, Edenton Map and Profile, and go over the information with the class. Then project the map. Distribute copies of both sides for students' reference.

3. Direct students' attention to the map of Edenton on Master 6.1a. On the basis of the information provided, and other knowledge of the community they have gained from the profile, ask students to identify

TEACHING CLUES AND CUES

In most parts of the country, there has not been any significant effort to coordinate community resources to respond to a major civic emergency like an earthquake. This planning scenario is intended to address an emergency resulting from an earthquake, but the process will yield procedures for dealing with other kinds of disasters as well.

all of the following. (The student who is playing the role of city manager will mark the transparency as indicated, using a different color for each type of information.)

a. at least one area where you could expect landslides, liquefaction failures, and/or fault ruptures. (These areas should be outlined and numbered.)

b. at least two groups of blocks where you could expect concentrated building damage. Include at least one commercial and one residential block group. (These areas should also be outlined and numbered, and may be referred to as Concentrated Damage Area 1,2,3, and so forth.)

c. major facilities, such as hospitals, schools, government buildings, and high rise buildings that might be rendered at least temporarily unusable by an earthquake or other natural disaster.

d. highway overpasses, roads, and other transportation facilities that might collapse or be left impassable by an earthquake.

4. As a review, and to focus students on the roles they have been learning about, ask each to prepare a brief job description. Have students exchange their job descriptions with each other and ask and answer questions until they are clear about the functions and responsibilities of each. Master 6.1b contains some sample job descriptions for your reference.

5. Once roles have been reviewed and job descriptions written, project Master 6.1c, Phases of an Effective Management Plan. Have the city manager convene the Edenton Emergency Management Planning Committee and call the meeting to order.

6. Students will work together to develop a plan. The city manager, referring to the Phases transparency, will remind the group that every plan must have three parts:

a. Before: preparations to be made before an emergency strikes, such as purchasing safety equipment, upgrading building codes, and educating the public.

b. During: strategies for emergency response during an earthquake or other crisis. Lines of communication will be particularly critical in this phase.

c. After: recovery plans for returning the community to conditions as normal as possible.

7. When the group has completed its emergency management plan, provide time for students to report the details of their plan. Help them to evaluate their plan by asking these questions:

- Is the plan realistic and timely?
- Is it comprehensive?
- Is it cost-effective?
- Do we have the resources to implement it? If not, how might we obtain additional resources?

TEACHING CLUES AND CUES

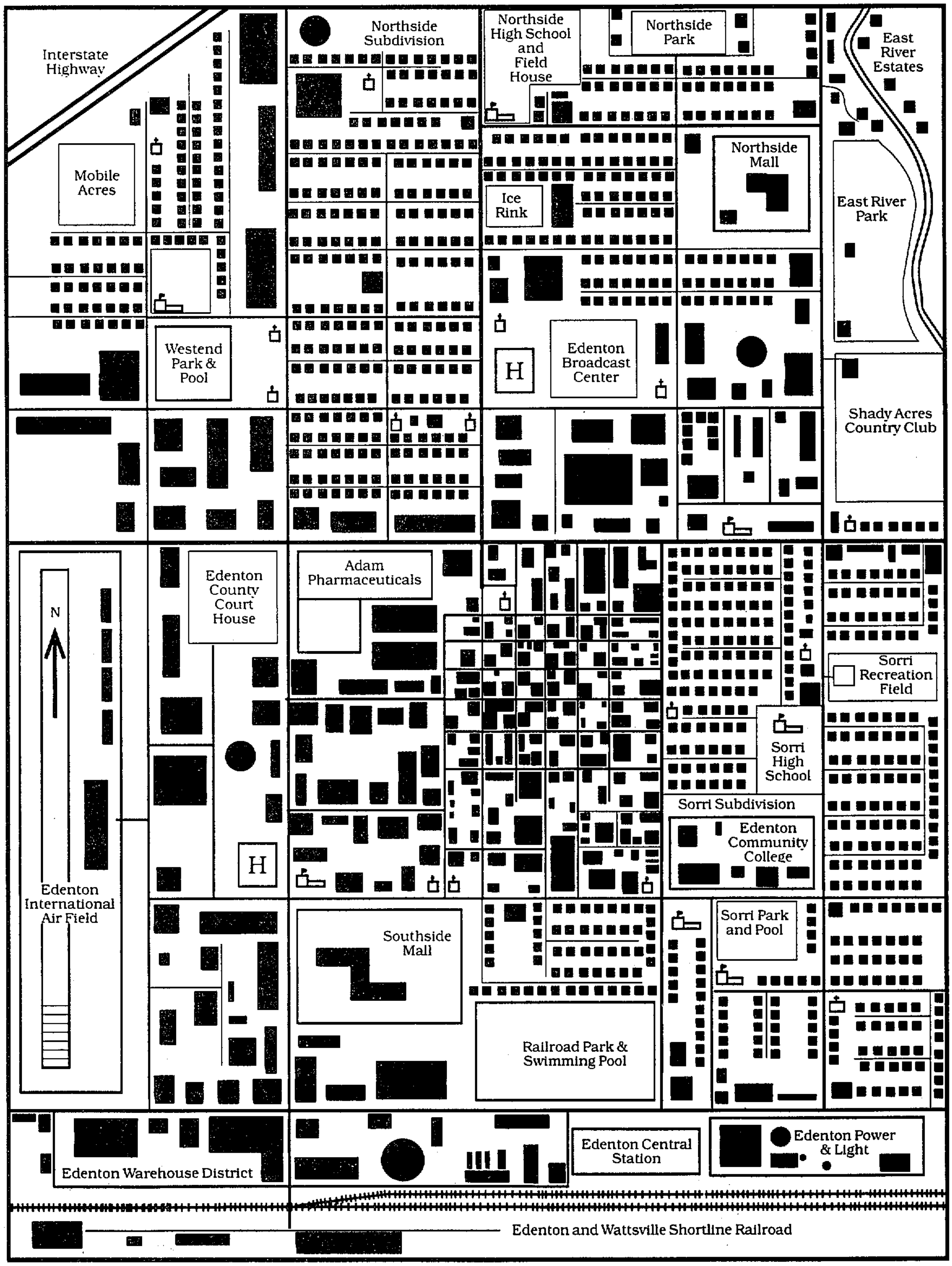
Be sure students understand that the lines they draw around these areas are only rough indications. In reality, each would be surrounded by a zone of influence, in which repercussions would also be felt.

Students may choose whether to work in committees for part of the planning period or to remain in one group.

C. Conclusion

Ask each student to augment her or his written job description with any particular responsibilities that will develop during a community crisis. Tell students that in the next activity they will have a chance to implement their plan. If questions arose in the planning process about how their city would function in an emergency, encourage students to contact their mentors before the next class meeting. ▲

Edenton Map


Interstate Highway
Mobile Acres
Northside Subdivision
Northside High School and Field House
Northside Park
East River Estates
Northside Mall
Ice Rink
East River Park
Westend Park & Pool
H
Edenton Broadcast Center
Shady Acres Country Club
N
Edenton County Court House
Adam Pharmaceuticals
Sorri Recreation Field
Sorri High School
Sorri Subdivision
Edenton Community College
H
Edenton International Air Field
Southside Mall
Sorri Park and Pool
Railroad Park & Swimming Pool
Edenton Warehouse District
Edenton Central Station
Edenton Power & Light
Edenton and Wattsville Shortline Railroad

Edenton Profile

Edenton, the county seat of Belle County, has a population of 150,000. The county itself has 300,000 citizens. As Belle County's only city, Edenton is the focal point of almost all services and activities. Its economy depends on a railroad repair facility operated by Amtrak and a large pharmaceutical manufacturing plant. These two operations are the city's largest employers. Because of its pleasant climate year round, its easy accessibility by interstate highways from all parts of the state, and a landscape that invites hunting, fishing, hiking, cycling, and camping, tourism in recent years has become an increasingly important part of the local economy.

Vital Statistics

Population—150,000

Schools
- 8 elementary schools
- 4 middle schools
- 2 high schools
- 1 community college

Communications
- 3 AM stations
- 1 FM station
- 1 television station
- 1 daily newspaper (The Lark)

Hospitals—2 (Mercy Hospital is a trauma center)

Police Department—150 officers/20 civilian employees

Fire Department—50 firefighters/10 civilian employees

Recreational System
- 8 city parks
- 3 swimming pools
- 4 fieldhouses
- 1 golf course

Houses of Worship—24

Airport—1 (within city limits; single runway; provides jet service)

Railroads—service by Amtrak

Highways—2 interstates converge five miles north of the city

Hotels—2 in center city, Motels—20, most in the areas served by the interstates

Libraries—Main library with 8 neighborhood branches (all single-story buildings)

Day Care Centers—10 licensed facilities

Nursing Homes—4

Retirement Communities—2

Mobile Home Parks—3

Shopping Malls—2

Power Plants—1 (oil/gas)

Water Supply—Aqueducts, pipelines, 2 pumping stations, 2 water treatment plants

Planning Roles

Chief of Police
The police chief is responsible for protecting lives and property in the area he serves. Specific responsibilities include preserving the peace, preventing criminal acts, enforcing the law, and arresting violators. The chief is under oath to uphold the law 24 hours a day. He or she makes many of the final decisions dealing with budgets and services provided by the police force.

Fire Chief
This official is responsible for protecting lives and property from the hazards of fire. Responsibilities include fighting fires, rescuing trapped individuals, conducting safety inspections, and conducting fire drills and fire safety education. The fire chief also assists in other types of emergencies and disasters in community life. He or she makes many of the final decisions dealing with budgets and services provided by the fire department. The fire chief usually comes through the ranks, starting as a firefighter.

Director of Public Works
This official is responsible for the maintenance of systems built at public expense for the common good, such as highways and dams. In some communities these responsibilities may be dealt with separately by officials responsible for highway safety and community transportation services, water and sewage, and other areas; in some, they may be combined in one office.

Director of Public Health
This official, usually a physician, is responsible for controlling the spread of communicable disease in the community and for mitigating any threats to the public safety, such as the contamination of public water supplies. He or she also engages in proactive education and advocacy to encourage positive behaviors, such as proper nutrition, and discourage negative ones, such as smoking and the abuse of alcohol and other drugs.

Coordinator of Community Transportation Services
This official is responsible for the safety of public transportation and both public and private vehicles. He or she arranges for registration, licensing, and state inspections. The coordinator inspects public vehicles and coordinates operation and maintenance of equipment, storage facilities, and repair facilities. She or he directs the recording of expenses and controls purchasing and repair spending. This official also helps plan and direct transportation safety activities.

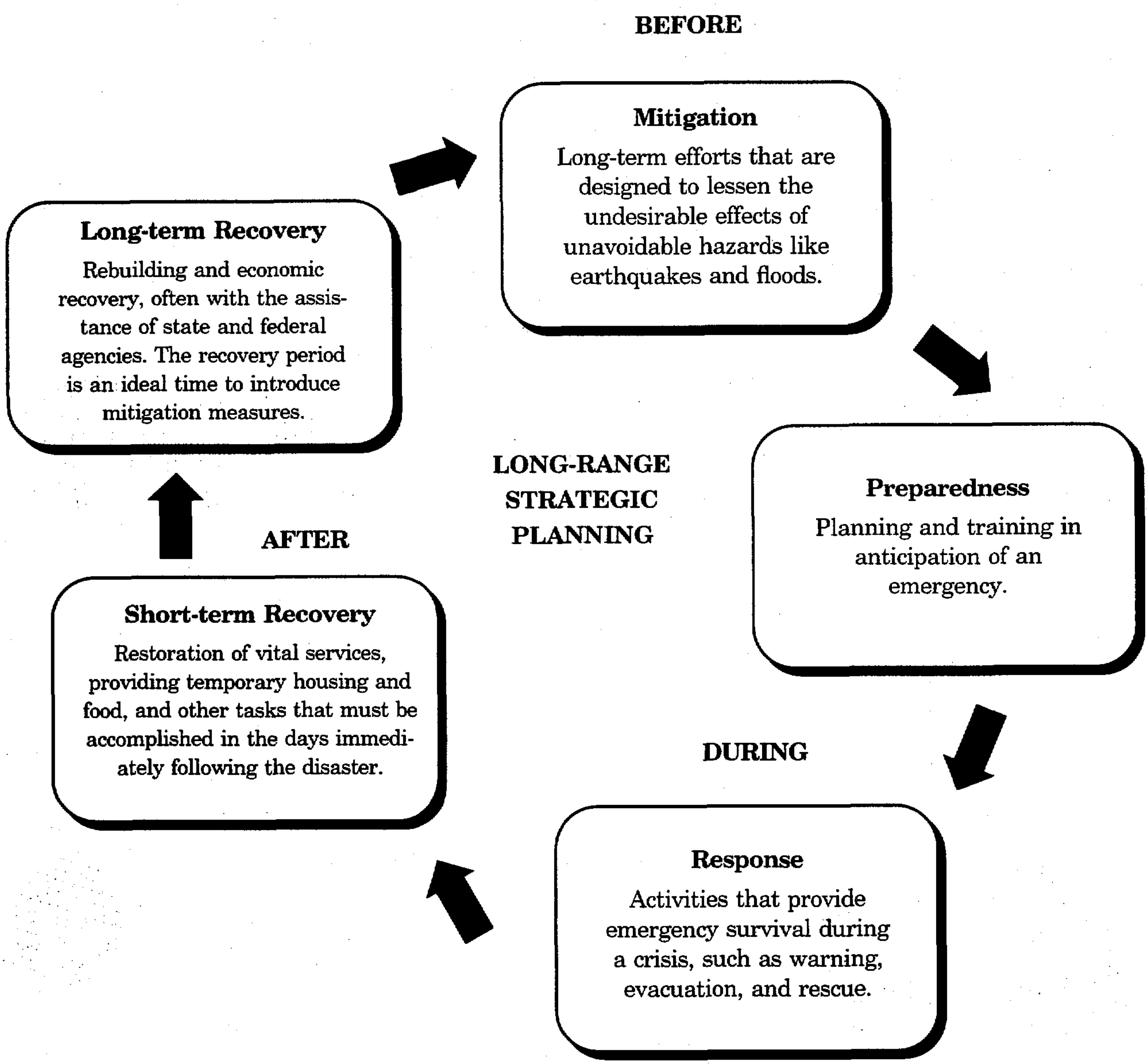
Public Information Officer
This official supervises a staff of public relations workers, directs publicity programs designed to inform the public, and directs information to appropriate groups. He or she clarifies the local government's points of view on important issues to community or public interest groups and responds to requests for information from news media, special interest groups, and the general public. In an emergency, this function assumes added importance.

Superintendent of Schools
This official is responsible for managing the affairs of an entire public school district. He or she oversees and coordinates the activities of all the schools in the district in accordance with standards set by the board of education. Responsibilities include selecting and hiring staff, negotiating contracts with union employees, and settling labor disputes. He or she creates and implements plans and policies for educational programs, and, when necessary, interprets the school system's programs and policies. The superintendent is also responsible for the development and administration of a budget, the maintenance of school buildings, and the purchase and distribution of school supplies and equipment, and oversees the school's transportation system and health services.

City Manager or Mayor
This professional in public administration has general responsibility for the overall operation of the city. All department heads answer to this official, who serves as the city's chief executive officer. A city manager is hired by the city council and serves at its discretion. A mayor is elected by the voters, but holds many of the same responsibilities.

Members of the City Council (as needed)
Each member determines the needs of the ward or district he or she represents by seeking out interviews, responding to constituents' phone calls and letters, and referring persons to specific agencies for services. The member speaks before neighborhood groups to establish communication and rapport between the members of the community and the service agencies available. The members of the council also have the responsibility to help resolve problems facing the community at large, in such areas as housing, urban renewal, education, welfare, unemployment, disaster response, and crime prevention.

Phases of an Effective Management Plan



6.2

EARTHQUAKE Simulation:

Putting Plans into Action

RATIONALE

Most emergency preparedness plans are never put into effect. In this activity students will have a chance to test the plans they have made, while also testing their own locality's state of emergency preparedness. By the end of this session, students should have a good geographic sense of their community and some understanding of how the rest of the community will react to emergencies.

FOCUS QUESTION

How current, comprehensive, and effective are your community's emergency preparedness plans?

OBJECTIVES

Students will:

1. Understand how a community government works and how it responds to emergencies.
2. Evaluate their locality's earthquake emergency preparedness plans.
3. Suggest changes in the existing emergency preparedness plan to reflect what has been learned.
4. Develop a personal earthquake emergency response.

MATERIALS

- Master 6.2a, Disaster Script
- Classroom community map (from Unit 1)

PROCEDURE

Teacher Preparation

Secure the cooperation of at least some of the mentors who have been working with your students throughout this curriculum. If possible, arrange for a place outside of school, such as a city government building, where students can conduct this simulation. Work with the mentors to develop a disaster script, using Master 6.2a as a beginning. Arrange to have at least one emergency preparedness official in attendance for this exercise and the debriefing that follows.

If your class has developed the community map they began in Unit 1, they will have a strong sense of their own community's physical and social arrangements. If not, you may want to work with the class to prepare a community profile similar to the Edenton Profile in Lesson 1 of this unit.

A. Introduction

Tell students that in this last unit of the Seismic Sleuths curriculum they will have a chance to draw on all that they have learned. Agree on a place to serve as the emergency command center. This may be a room at city hall, if you have made previous arrangements; your school auditorium; or a circle of chairs in the front of your own classroom. The community map will be the focal point of this area.

B. Lesson Development

1. Have the student who is playing the role of mayor or city manager convene a meeting of the preparedness council established in the last lesson. The purpose of this meeting is to discuss the budget of each department and clarify each administrator's role in an emergency. Focus on the lines of communication and each person's response to specific emergency situations (major fire, tornado, flood, earthquake, chemical plant disaster, etc.—focus on those most likely in your community). Whoever conducts the meeting will use the large community map to plot where each person's main area of interest lies and what geographic areas are essential to maintaining the continuity of essential services, such as water treatment, sewage treatment, and electrical power.

2. After 10 minutes or more, when the main points have been reviewed, but without warning, tell the students that an earthquake is occurring. Conduct a drop, cover, and hold drill, following the instructions in Unit 5, Lesson 2. Immediately after the drill, begin reading the script. Explain the time frame of the exercise. Students should then begin to take control of the situation and implement their emergency plans.

C. Conclusion

At the next class meeting, set aside some time for a debriefing and evaluation. Give students class time to write thank-you letters to their mentors and other members of the community who participated in this exercise and/or in earlier lessons. Mail the letters from school.

ADAPTATIONS AND EXTENSIONS

1. Encourage students who have shown particular interest to maintain contact with their mentors, perhaps through volunteer work, a part-time job, or a request for career information. This association may inspire some students' choice of a career.

2. Write your own letters of appreciation to any community helpers who have not worked directly with individual students. With encouragement, some of these individuals may maintain an interest in the school and become valuable resources for students and faculty. ▲

TEACHING CLUES AND CUES

This activity can be as elaborate as you choose to make it. You may want to set aside a half day, or even a full day.

The appendix that follows this unit is a report of an actual teacher-planned community earthquake preparedness drill. This is incorporated as a framework to use in constructing such an activity for your community.

Disaster Script

At 10:05 a.m. today, Tuesday, September 26, 1995, a magnitude 7.0 earthquake struck the community. At noon, the following damage had been reported:

The downtown area was hardest hit. People have reported that most shelves, bookcases and display stands were knocked over. Masonry structures have sustained major damage, brick facades are collapsing, chimneys are falling, and some buildings have serious structural cracks. No fatalities have yet been reported.

The hospital reports that its three-story gerontology unit has "pancaked," causing the second and third floors to collapse on the first floor. At the time of collapse, 34 persons—29 patients and 5 staff members—were in that part of the building. Other parts of the hospital suffered nonstructural damage, some disruption to power, and an end to all but lifesaving procedures. The latest information indicates that the hospital will be at 50% operational capacity by 2:30 this afternoon.

Of the three fire stations, two have stayed operational. The downtown station has been destroyed. Fire department personnel were able to move only one pumper wagon before the building collapsed on the ladder truck, ambulance, and emergency generator truck.

This can be changed, embellished, tailored, and expanded for your community and your students. Additional effects that may be included:

- Large fire has broken out in downtown area
- Water mains are cut
- 20% of the population has sustained injuries
- Utility lines are down
- Animals in the zoo have escaped from their cages
- Looters are rampaging through downtown
- Sewers have backed up, endangering public health

6.3

What's Your E.Q. I.Q.?

RATIONALE

Students will review and solidify what they have learned in the preceding units by answering questions in cooperative teams.

FOCUS QUESTION

How well can student's recall and apply what they have learned?

OBJECTIVES

Students will:

1. Ask and answer questions about earthquakes and earthquake preparedness.
2. Keep score.
3. Learn from incorrect responses as well as correct ones.

MATERIALS

- Master 6.3a, Earthquake Review Questions
- Back of Master 6.3a, Answer Key
- Minute timer
- Chalkboard and chalk for recording the score
- Tag board and laminating materials (*optional*)

PROCEDURE

Teacher Preparation

Copy Master 6.3a and cut the pages apart into cards. You may want to back them on tag board and/or laminate them for durability.

A. Introduction

Divide the class into teams of four or five students each and give each team a number or a name.

Give groups about 15 minutes to review the earthquake materials in their notebooks and ask each other questions as a warm-up.

TEACHING CLUES AND CUES

Students may enjoy competing in the teams they established for the unit 4 activities (SETs).

B. Lesson Development

1. Call two teams at a time to the front of the room. Instruct students to arrange chairs in two rows facing each other. Hand the deck of question cards to one team. For the first round, this team will ask and the other team will answer.

2. Asking and answering both begin with the student on the left. The first asker reads a question out loud and starts the timer. The first student on the opposing team tries to answer it. If that student cannot answer the question, play passes to the second student on the same team, then to the third, if necessary, and so on until one minute is up. The questioning team keeps score, tallying one point for each correct answer.

3. When any member of the team that is up answers incorrectly, play passes to the other team and the roles are reversed. When a member of the second team answers incorrectly, call two new teams to the front of the room.

C. Conclusion

When all the teams have had a chance to play, the team with the highest score may challenge any other team to a new round. If another team exceeds their score, they become the new challengers. The team with the highest score at the end of the period wins.

ADAPTATIONS AND EXTENSIONS

Invite students to write questions and answers of their own to add to the deck. Be sure that all members of a group agree on the answer and the phrasing of the question before the card is put into play. ▲

TEACHING CLUES AND CUES

When all the cards have been used once, shuffle them and begin again. Repetition reinforces learning.

EARTHQUAKE Review Questions

SEISMIC SLEUTHS

1. According to geologic studies, approximately how old is the Earth?

[a] 2 thousand years
[b] 7 thousand years
[c] 2 million years
[d] 4.54 billion years

SEISMIC SLEUTHS

2. All of the following people made major contributions to our knowledge of the Earth's physical history and structure except:

[a] Alfred Wegener
[b] Inge Lehmann
[c] Anna Maria Alberghetti
[d] Andrija Mohoroviçic

SEISMIC SLEUTHS

3. Earthquakes are caused by:

[a] strain energy that builds up and is suddenly released
[b] tides
[c] bad vibrations
[d] the Richter scale

SEISMIC SLEUTHS

4. Approximately how many earthquakes large enough to be rated significant by the U.S. Geological Survey occur worldwide during a calendar year?
[a] More than 20
[b] More than 100
[c] More than 1000
[d] More than 15,000

SEISMIC SLEUTHS

5. Although earthquakes occur almost everywhere, strong, damaging quakes are especially common in the:

[a] Eastern United States
[b] Pacific Ring of Fire
[c] Mediterranean Region
[d] Great African Rift

SEISMIC SLEUTHS

6. Which of these statements best describes the relationship between earthquakes and volcanoes?

[a] Earthquakes cause volcanoes.
[b] Volcanoes cause earthquakes.
[c] Volcanoes and earthquakes both occur along the margins of Earth's tectonic plates.
[d] Volcanoes only occur in hot countries.

SEISMIC SLEUTHS

7. Scientists can accurately predict earthquakes in the short range by studying:

[a] the behavior of animals
[b] changes in radon emissions
[c] Rayleigh waves
[d] none of the above

SEISMIC SLEUTHS

8. The Richter scale measures an earthquake's:

[a] magnitude
[b] amplitude
[c] pulchritude
[d] intensity

Answer Key

SEISMIC SLEUTHS b	SEISMIC SLEUTHS d
SEISMIC SLEUTHS c	SEISMIC SLEUTHS c
SEISMIC SLEUTHS d	SEISMIC SLEUTHS a
SEISMIC SLEUTHS a	SEISMIC SLEUTHS d

SEISMIC SLEUTHS

9. How much greater is the amount of energy released by a magnitude 7 earthquake than the amount released by a magnitude 6 quake?

[a] twice as great
[b] 10 times as great
[c] about 30 times as great
[d] 100 times as great

SEISMIC SLEUTHS

13. In which one of these states are strong and potentially damaging earthquakes relatively frequent?

[a] Texas
[b] Florida
[c] Wisconsin
[d] Alaska

SEISMIC SLEUTHS

10. The method architects and structural engineers use to quickly assess a building's earthquake resistance is called:

[a] eyeballing
[b] sedimentation
[c] rapid visual screening
[d] estimating

SEISMIC SLEUTHS

14. If a strong earthquake struck while you were inside a building, what would you do to protect yourself?

[a] run outside
[b] dial 911
[c] drop, cover, and hold
[d] freeze

SEISMIC SLEUTHS

11. The earthquake waves that are the first to arrive at the epicenter are called:

[a] P waves
[b] A waves
[c] First waves
[d] Love waves

SEISMIC SLEUTHS

15. How much damage a building suffers in an earthquake depends upon:

[a] how close it is to the fault
[b] what it is built of and how it is built
[c] what kind of soil it is built on
[d] all three

SEISMIC SLEUTHS

12. About how long does the violent shaking last in a typical earthquake?

[a] 20 seconds
[b] one minute
[c] five minutes
[d] 30 minutes

SEISMIC SLEUTHS

16. To make a room safer in an earthquake, you would:

[a] fasten all unsecured heavy objects
[b] remove all pets
[c] turn on the radio
[d] lock the doors and windows

Answer Key

SEISMIC SLEUTHS d	SEISMIC SLEUTHS c
SEISMIC SLEUTHS c	SEISMIC SLEUTHS c
SEISMIC SLEUTHS d	SEISMIC SLEUTHS a
SEISMIC SLEUTHS a	SEISMIC SLEUTHS a

SEISMIC SLEUTHS

17. A break in the Earth's crust along which earthquake movement has occurred is called:

[a] a gap
[b] a fault
[c] an epicenter
[d] an isoseismal

SEISMIC SLEUTHS

18. A gigantic ocean wave caused by an earthquake is called:

[a] a samurai
[b] a sand boil
[c] a tsunami
[d] a surface wave

SEISMIC SLEUTHS

19. All of the following are structural elements except:

[a] windows
[b] bearing walls
[c] braces
[d] horizontal beams

SEISMIC SLEUTHS

SEISMIC SLEUTHS

20. All of the following are good sources of earthquake information except:

[a] United States Geological Survey
[b] The National Enquirer
[c] Federal Emergency Management Agency
[d] National Earthquake Prediction Evaluation Council

SEISMIC SLEUTHS

21. Resonance is a buildup of amplitude in a physical system that occurs when the frequency of an applied oscillatory force is close to the natural frequency of the system.
[a] true
[b] false
[c] sometimes
[d] don't know

SEISMIC SLEUTHS

SEISMIC SLEUTHS

Answer Key

SEISMIC SLEUTHS b	SEISMIC SLEUTHS b
SEISMIC SLEUTHS a	SEISMIC SLEUTHS c
SEISMIC SLEUTHS	SEISMIC SLEUTHS a
SEISMIC SLEUTHS	SEISMIC SLEUTHS

HEY, Look at Me Now!

RATIONALE

This activity is designed to serve students and teachers as a gauge of what they have learned from this curriculum.

FOCUS QUESTIONS

What have you learned about earthquakes and earthquake preparedness?

What will you do differently as a result of these lessons?

OBJECTIVE

Students will correct, elaborate, and refine their earlier writings by applying information they have gained from this curriculum.

MATERIALS

- Writing paper and pens or computers and printers

PROCEDURE

A. Introduction

Explain that in this postassessment activity each student is to complete the same task he or she did in the preassessment activity. In rewriting each of the three passages, however, students are urged to draw upon what they have learned from the unit. Remind the students to focus on how their new knowledge has changed their way of thinking about earthquakes and earthquake preparedness.

B. Lesson Development

As they did in Unit 1, students will invent a specific quake. Each of their three accounts will describe the same earthquake, but the styles of the three will vary.

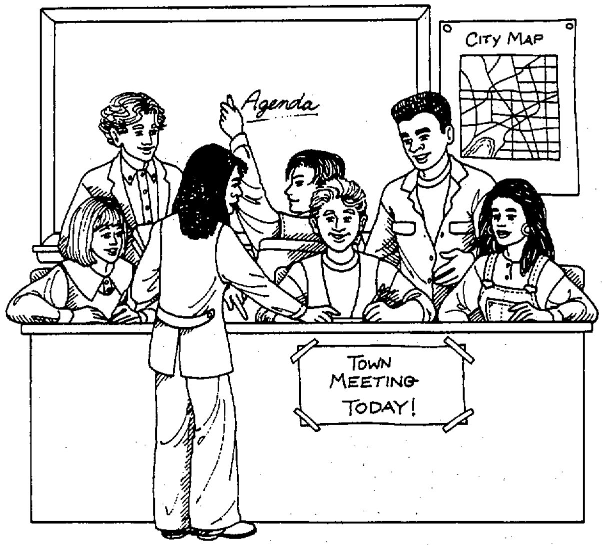
News Reporter—a short, concise article describing the who, what, where, why, and when of the earthquake.

Scientist—a scientific account stating what is objectively known about the earthquake: its causes, its Modified Mercalli and Richter ratings, and the possibility of aftershocks or more large earthquakes.

Eyewitness—a personal letter to a friend telling about being in an earthquake. This will describe what happened during the earthquake to the student, the building in which the student was, family members and pets, and the family home. Describe what you had done before the earthquake to be prepared, how effective your preparations were, and what you would do differently in preparation for the next earthquake. Also describe what life was like in the two weeks following the earthquake.

C. Conclusion

After collecting the papers, pair each student's postassessment writings with the same student's preassessment writings, and hand them out to a different student. Assign students the task of reading both sets and commenting on what the writer has learned from the unit. Follow with a class discussion of these comparisons, either the same day or the next. ▲



Books

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Non-Print Media

Silent Quake: Preparedness for the Hearing-Impaired. A videotape using American sign language, captioning, and voice-overs. Developed by the American Red Cross, Los Angeles, CA, available on loan from BAREPP, Oakland, CA; 415-327-6017.

***Note:** Inclusion of materials in these resource listings does not constitute an endorsement by AGU or FEMA.*

EARTHQUAKE Drill:
A Critical Skills Exercise

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Abstract
Earth science students at Salem High School have participated in an environment of critical skills. Events are student centered, learning stresses both process and curriculum content, and the foundation for activity is problem-solving projects. This particular project had students designing and rehearsing part of an emergency management plan in response to a hypothetical earthquake affecting Salem, NH. Students assumed the roles of town officials in a three-hour drill held in Salem's Emergency Operations Center (EOC). The drill was sponsored by the town of Salem and the New Hampshire Office of Emergency Management. Project origin, planning, performance, and follow-up are detailed in this paper.

Introduction
For seven months students in this class spent more than 100 hours not only learning about specific topics in Earth science but also learning specific strategies for learning and working together. In March, as our plate tectonics unit progressed, the time to apply our learning had arrived. A project was designed in cooperation with our town's emergency management director and the New Hampshire Office of Emergency Management.

In this project students were to design, document, and use a hazard plan to be added to Salem's Emergency Management Plan for earthquake response. Students did extensive research and documentation, preparing a plan and also preparing themselves to play roles as decision makers in a disaster. The teacher, the emergency management director, and Office of Emergency Management staff members met and communicated many times to finalize the details.

The actual drill, held in Salem's Emergency Operations Center (EOC), greatly surpassed all expectations. Students handled crisis after crisis as part of a three-hour drill that included mass destruction, dam failure, utility outages, looting, hospital closings, and multiple evacuations. Groups of students rotated through three one-hour shifts filling various roles in turn, including those of the school superintendent, reporters, and selectmen. There was confusion and near hysteria as a myriad of details crowded the EOC. Students struggled at times to prioritize and solve problems. All the participants and observers came away with a new respect for each other and a new appreciation of the need to be prepared for the worst.

How It All Began
Teaching in this class proceeds from the philosophy that learning is a very complex behavior. Learning is different for each individual, and schools need to recognize these differences. Schools also need to teach not only the "what" but also the "how" of learning. With this in mind, these 96 people were provided a student-centered environment that made them ultimately responsible for their learning both as individuals and as a group. Students spent many class periods doing activities that provided experience with various learning styles. Projects were used to create concrete and abstract opportunities for learners, including reading, writing, coordinating, prioritizing, and communicating.

Emphasis is placed on the belief that there are often many viable solutions to a problem. For this reason, creativity is strongly fostered, as students are urged to produce quality work from their own base of knowledge and experience. The teacher is not the "fountain of knowledge." Students must find their own answers that they can support fiercely and intimately. Guidance and direction are given in the form of specific teacher questions. As students gain experience and comfort completing curriculum-based projects in this student-centered class, they begin to take more control of their education, needing less teacher input. With greater student responsibility, the teacher's goal is to balance content and process so that each remains equally valued in learning.

Earthquake in Salem, NH

So why dabble with earthquakes, not to mention the town's Emergency Management Plan? Because high school students are interested in earthquakes. Earthquakes are unpredictable, damaging, and loud—characteristics admired and even shared by many teenagers. Moreover, the teachers saw a need for earthquake education, preparedness, and response within the community.

In preparation for this major project, classes throughout the year dealt with process strategies and critical skills. Skills including decision making, problem solving, communication, cooperation, and documentation were addressed, rehearsed, refined, and incorporated into our classes. Additionally, students carried out many short-term projects in the field of plate tectonics and seismology. Specifically, students researched, modeled, and demonstrated types of seismic waves, seismic forecasting, hazard assessment, and New England's seismic history.

The next step in the project involved a contact with the person in Salem responsible for emergency management. The teacher had to determine if the anticipated needs existed and whether or not direct community involvement was possible. Salem's fire chief, who also serves as its emergency management director, acknowledged a void in the town's disaster response and was completely open to student input and community cooperation. As the teacher and the director discussed their needs, the project evolved into what they hoped would be a truly meaningful experience. Ninety-six of Salem's teenagers might permanently and positively affect their community.

The teacher expressed the following goals:

A. Students will develop and implement a solution with an educational component to a real problem in our community. They will:

1. do community-based research
2. incorporate many information-gathering techniques
3. use a maximum number of resources
4. use pre-existing models and/or plans where appropriate

B. Students will select, implement, and refine certain process skills, such as decision making, problem solving, communication, cooperation, and documentation.

C. Students will be able to describe all major theories on plate tectonics as well as how those theories relate to earthquakes.

D. Students will be able to describe New England's earthquake history and its susceptibility to future seismic activity.

E. The adults will empower students to come up with their own plan in an open environment with a minimum of restrictions.

Planning, Planning, and More Planning

The director suggested a drill that would test the students' solutions as a way of summing up and evaluating the project. This drill would not only satisfy the teacher's desire to test students, but also provide a rehearsal of the town's Emergency Management Plan. The teacher and the director outlined the town's need for a hazard plan and discussed the specific ways in which students might meet that need. A time and date for the drill were set, and a letter to the students was drafted, recognizing their recent experiences in these areas and requesting their aid.

The next task was kicking off this 15-day extravaganza by arranging for expert speakers to come into the school. Issues discussed included seismology, engineering, hazard assessment, emergency response planning, and plan implementation. All of our guest experts graciously supplied printed materials to supplement their presentations.

On kick-off day, the educators and the experts decided students needed additional guidelines to properly design a hazard plan. The design of the plan was separated into five areas—communication, evacuation, hazard assessment, private resources, and public resources. As the first few days passed, students struggled to prioritize the components of the problem and divide up responsibilities. The teacher carefully guided students by questioning them and challenging them to use skills and knowledge they had already developed.

Meanwhile, the director scripted the drill, provided the teacher with the roles and titles students would assume during the drill (see list below), and secured access to a wide variety of resources. The resources included a college text, Federal Emergency Management Agency (FEMA) pamphlets, and a blank hazard plan illustrating plan design. Also made available were the telephone numbers of the town's department heads and of state and regional emergency management personnel, and lastly, the most precious resource of all, personal attention and dedication. The New Hampshire Office of Emergency Management and its natural hazards program specialist also provided generous amounts of both time and materials.

EOC Town Officials and Staff Roles

TOWN OFFICIALS

Chairman, Board of Selectmen
Members, Board of Selectmen (4)
Town Manager
Emergency Management Director
Fire Chief
Police Chief
Public Works Director
Health Officer
Chief Building Inspector
Director of Human Resources (Welfare)
American Red Cross Director
Superintendent of Schools

EOC STAFF

Message Loggers (2)
Message Runners (2)
Updater, Status Board (1)
Radio Communications (2
EOC Security (2)
EOC Logistics (2)
Public Information Officer
Reporters (3)

As the project continued, the teacher noticed an ever-increasing level of student anxiety and misdirection. Therefore, the teacher and the director arranged for a debriefing of the project's progress. The students presented their ideas and findings to a panel consisting of the director, educators, and the New Hampshire natural hazards specialist. The panel was able to give students valuable feedback on their plan's strengths and weaknesses. This day-long debriefing also allowed students a chance to look at the project from a critical point of view, breathing new life into their design and implementation efforts.

At the beginning of the second week, the teacher finalized student sign-up for the roles they were to assume in a three-shift rotation. Each student selected (1) a decision making role, where he or she would play an active part in the Emergency Operations Center (EOC), and (2) an EOC staff role or a role with rescue equipment and media presentations. Each student also had to identify one shift during which to start a journal, recording not only observations of the drill's varied actions and reactions, but also an introspective analysis of the project's progression from start to finish.

The director coordinated the attendance of the town's department heads, the school superintendent, the American Red Cross representative, a utility company representative, and the media, as well as state and regional emergency management officials. The director and the teacher finalized details and made arrangements for physically disabled and motivationally disabled students, school and community rules implementation, lunch, and debriefing.

It's D-Day!

At 8:30 a.m. on D-Day (Drill Day), students anxiously gathered materials and boarded the bus to Salem's EOC, not knowing quite what to expect. Upon arrival at the Main Street fire station housing the EOC, students heard building rules and consequences, dropped off their coats, and positioned themselves for the first shift of the drill. With Salem's youth in place as fire and police chiefs, building inspector, school superintendent, radio operator, message runners, EOC security, and newspaper reporters, the EOC opened and the drill began.

The script for the day explained that the EOC had been opened in response to an earthquake at 7:50 a.m., measuring 7.5 on the Richter scale and centered in nearby Hudson, NH. With Salem's adult department heads as advisors, students enacted their plan, prioritizing needs, communicating with counterparts, and solving problems, all while using the town's minimal remaining resources as judiciously as possible.

An excerpt from the drill script details the crisis students were reacting to.

SHIFT CHANGE - STATUS REPORT

It is now 8:00 am (the second morning).

During the night, the public works department began repairs on the known broken water mains. The water towers are back up to capacity, but water service is provided to only a small portion of the town (Main St./Depot area and Lawrence Rd./Cluff Rd. area).

The sewer system is completely out of service and sewerage is beginning to leak into some streams and onto roads. All power in town went out for most of the night and is beginning to come on in sections. Cable TV is still out. The cracks in the dam at Arlington Pond appear to be worsening.

The evacuation center has housed approximately 200 people who are in need of food.

The Police Department spent a long night dispersing looters and making arrests. Approximately 20 people are in custody.

The Fire Department responded to several building collapses, two house fires, numerous downed power lines, and 15 ambulance calls. Most of the patients were taken to a temporary first aid station.

Two relatively minor aftershocks were felt during the night.

Decisions are made, aid is rendered, and nerves are wracked as each shift struggles with a seemingly endless onslaught of high-priority problems. At times, the EOC becomes a jumble of noise and confusion. Internal communication deteriorates and priorities temporarily blur. Selectmen try to solicit information from the building inspector, only to find him tied up with both the public works director and the health official. Finally, the emergency management director shouts for order, quieting the din and returning the EOC to a semblance of organization. After 180 minutes, simulating 24 hours of emergency responses highlighted by a telephone call from the Director of FEMA, Mr. Stickney, the drill concludes with a press conference.

As we await the arrival of lunch, all participants are relieved, excited, exhausted, and slightly saddened to know the project has reached its end. Students share the disasters and the responses of each shift. Some write feverishly in their journals, not wanting to forget a single moment. As the 30 pizzas arrive, students and staff alike enjoy a carefree lunch and conversation.

With lunch cleared away, the group assembles for the anticipated critique and debriefing. Town and state emergency management officials have many kind words for the students, followed by praise from Salem's emergency management director and the teacher. In spite of the positive input, students decide that their hazard plan can be improved, and request permission to keep the document for that purpose.

At 1:15 p.m., the students, document in hand, say their good-byes and their thanks as the teachers and directors shake hands. After a short ride, the once and future emergency managers are back in school, heading off to their last-period class. These 96 young teens have had the experience of a lifetime, gaining a priceless perspective on their community and themselves.

Project Strengths and Weaknesses

The success of the project far exceeded all expectations. Students were able to not only synthesize a plan for dealing with a natural disaster, but also put their plan into action. There were some areas of concern, however.

Even though the plan allotted 15 decision-making roles, representing town officials, and another 15 staff roles in the EOC, there were several students who had to double up in order to participate in the EOC's operation. The EOC was always overcrowded with students, adult advisors, state and regional observers, and media.

The strengths were numerous. This activity was truly student centered. Students took the initiative in researching and preparing the plan, several times even meeting after school and on weekends. Additionally, students had to make dozens of community contacts to gather materials and information. There was a rush of positive public relations for both the school and the town of Salem. Print media from Lawrence, MA, and Salem, NH, as well as TV news from Manchester, NH, covered the drill. Most satisfying to the teacher, the students ended the experience still wanting to do more, as they communicated through their lengthy and detailed journals.

EARTHQUAKE Glossary

Aftershock—an earthquake that follows a larger earthquake, or main shock, usually originating along the same fault as the main shock.

Amplitude—a measurement of the energy of a wave. Amplitude is the displacement of the medium from zero or the height of a wave crest or trough from a zero point.

Body waves—waves that move through the body (rather than the surface) of the Earth. P waves and S waves are body waves.

Braces or Bracing—structural elements built into a wall to add strength. These may be made of various materials and connected to the building and each other in various ways. Their ability to withstand stress depends on the characteristics of the materials and how they are connected.

Canopy—a covered area that extends from the wall of a building, protecting an entrance.

Cantilever—a beam, girder, or other structural member which projects beyond its supporting wall or column.

Cartographer—a map maker.

Cladding—an external covering or skin applied to a structure for aesthetic or protective purposes.

Cornice—the exterior trim of a structure at the meeting of the roof and wall.

Compression—squeezing, being made to occupy less space. P waves are called *compressional waves* because they consist of alternating compressions and dilations, or expansions.

Consolidated—tightly packed, composed of particles that are not easily separated.

Continental drift—the theory, first advanced by Alfred Wegener, that Earth's continents were originally one land mass, pieces of which split off and gradually migrated to form the continents we know.

Diagonal braces—structural elements that connect diagonal joints. These braces may be made of solid materials or flexible materials. How they function depends on what they are made of and how they are connected.

Duration—the length of time that ground motion at a given site shows certain characteristics. Most earthquakes have a duration of less than one minute, in terms of human perceptions, but waves from a large earthquake can travel around the world for hours.

Earthquake—a sudden shaking of the ground caused by the passage of seismic waves. These waves are caused by the release of energy stored in the Earth's crust.

Earthquake hazard—any geological or structural response to an earthquake that poses a threat to human beings and their environments.

Elevation—in architecture, a flat scale drawing of one side of a building.

Epicenter—the point on Earth's surface directly above the location (focus) of the earthquake below the surface.

Epitaph—an inscription on a tombstone, often intended to sum up the achievements of a person's life.

Fault—a break or fracture in Earth's crust along which movement has taken place.

Focus (pl. foci)—the point within the Earth that is the origin of an earthquake, where stored energy is first released as wave energy.

Force—the cause or agent that puts an object at rest into motion or affects the motion of a moving object. On Earth, gravity is a vertical force; earthquake shaking includes both horizontal and vertical forces.

Foreshock—an earthquake that precedes a larger earthquake, or *main shock*, usually originating along the same fault as the main shock.

Friction—mechanical resistence to the motion of objects or bodies that touch.

Frequency—the rate at which a motion repeats, or oscillates. The frequency of a motion is directly related to the energy of oscillation. In this context, frequency is the number of oscillations in an earthquake wave that occur each second. In earthquake engineering, frequency is the rate at which the top of a building sways.

Generalization—a statement made after observing occurrences that seem to repeat and to be related.

Glazing—glass surface.

Gravity—the force of attraction between any two objects with mass. Gravity is especially noticeable when an object of great mass, such as Earth, attracts an object of lesser mass.

Ground water—subsurface or underground water.

Hazard—an object or situation that holds the possibility of injury or damage.

Hertz (Hz)—the unit of measurement for frequency, as recorded in cycles per second. When these rates are very large, the prefixes *kilo* or *mega* are used. A *kilohertz* (kHz) is a frequency of 1,000 cycles per second and a *megahertz* (MHz) is a frequency of 1,000,000 cycles per second.

Horizontal load—the sum of horizontal forces (shear forces) acting on the elements of a structure.

Index fossil—a fossil that, because its approximate date is known, allows scientists to determine the age of the rock in which it is imbedded.

Infill—a construction method that starts with a structural steel or reinforced concrete frame and fills the empty spaces between structural elements with brick or hollow concrete block.

Intensity—a subjective measure of the amount of ground shaking an earthquake produces at a particular site, based on human observations of the effect on human structures and geologic features. The Modified Mercalli Intensity scale uses Roman numerals from I to XII.

Isoseismal line—a line on a map that encloses areas of equal earthquake intensity.

Joint—a break or fracture in the Earth's crust along which movement has not taken place.

Joists—the parallel planks or beams that hold up the planks of a floor or the laths of a ceiling.

Lag time—the difference between the arrival time of P waves (T_p) and S waves (T_s).

Landfill—a site where soil has been deposited by artificial means—often, where garbage or rubbish has been disposed of, then covered with dirt and compacted.

Landslide—an abrupt movement of soil and bedrock downhill in response to gravity. Landslides can be triggered by an earthquake or other natural causes.

Latitude—the location of a point north or south of the equator, expressed in degrees and minutes. Latitude is shown on a map or globe as east-west lines parallel to the equator.

Lifeline—a service that is vital to the life of a community. Major lifelines include transportation systems, communication systems, water supply lines, electric power lines, and petroleum or natural gas pipelines.

Liquefaction—the process in which a solid (soil) takes on the characteristics of a liquid as a result of an increase in pore pressure and a reduction in stress.

Load—the sum of vertical force (gravity) and horizontal forces (shear forces) acting on the mass of a structure. The overall load is further broken down into the loads of the various parts of the building. Different parts of a building are designed and constructed to carry different loads.

Load path—the path a load or force takes through the structural elements of a building.

Loess—an unstratified, windblown mixture of clay, sand, and organic matter, usually crumbly and buff or yellow-brown in color.

Longitude—the location of a point east or west of the prime meridian, expressed in degrees and minutes. Longitude is shown on a map or globe as north-south lines left and right of the prime meridian, which passes through Greenwich, England.

Longitudinal waves—p-waves. This term is used to emphasize that p-waves move particles back and forth in the same line as the direction of the wave.

Love waves—surface waves that move in a back and forth horizontal motion.

Magnitude—a number that characterizes the size of an earthquake by recording ground shaking on a seismograph and correcting for the distance to the epicenter of the earthquake. Magnitude is expressed in Arabic numbers.

Masonry—stone, brick, or concrete building materials.

Masonry veneer—a masonry (stone or brick) facing laid against a wall and not structurally bonded to the wall.

Mass movement—the movement of surface material caused by gravity.

Meteorology—the study of Earth's atmosphere.

Modified Mercalli scale of 1931—a qualitative scale of earthquake effects that assigns an intensity number to the ground shaking for any specific location on the basis of observed effects. Mercalli intensity is expressed in Roman numerals.

Natural hazard—any of the range of natural Earth processes that can cause injury or loss of life to human beings and damage or destroy human-made structures.

Nonstructural feature—an element of a building that is not essential to its structural design and does not contribute structural strength. Examples are windows, cornices, and parapets.

Oscillation or vibration—the repeating motion of a wave or a material—one back and forth movement. Earthquakes cause seismic waves that produce oscillations, or vibrations, in materials with many different frequencies. Every object has a natural rate of vibration that scientists call its *natural frequency*. The natural frequency of a building depends on its physical characteristics, including the design and the building materials.

P waves—primary waves, so called because they travel faster than S waves, or secondary waves and arrive at the station first. These waves carry energy through the Earth as longitudinal waves, moving particles in the same line as the direction of the wave.

Paleomagnetism—the natural magnetic traces that reveal the intensity and direction of Earth's magnetic field in the geologic past.

Paleoseismology—the study of ancient earthquakes.

Parapet—part of a wall which is entirely above the roof.

Path, or Load path—the direction in which energy is distributed throughout a structure. In most structures, it should be directed toward the ground.

Peat—a deposit of semicarbonized plant remains in a water-saturated environment. Peat is an early stage in the development of coal.

Period—the time between two successive wave crests.

Pioneer—a person who moves into new and uncharted territory.

Plate tectonics—the theory that Earth's crust and upper mantle (the lithosphere) are broken into a number of more or less rigid, but constantly moving, segments, or plates.

Portico—a porch or covered walk consisting of a roof supported by columns

Prediction—a statement that something is likely to happen based on past experience. A prediction is usually only as reliable as its source.

Principle of crosscutting relationships—the principle stating that a rock is always younger than any other rock across which it cuts. Earthquake faulting illustrates this principle: Faults are always younger than the rocks they cut.

Principle of superposition—the principle upon which all geologic chronology is based stating that in any sequence of sedimentary layers that has not been overturned or faulted, each layer is younger than the one beneath, but older than the one above it.

Principle of uniformitarianism—the fundamental principle stating that geologic processes have operated in essentially the same way throughout geological time.

Probability—in mathematics, the ratio of the number of times something will probably occur to the total number of possible occurrences. In common usage, an event is probable, rather than merely possible, if there is evidence or reason to believe that it will occur.

Qualitative—having to do with perceived qualities; subjective. Examples: large, cold.

Quantitative—having to do with measurable quantities; objective. Examples: 10 m long, 5° C.

Radiometric dating—the process of using natural radioactivity to determine the age of rocks.

Rapid visual screening (RVS)—a method of assessing risk that relies on external observation. An observer who is trained in RVS can derive enough information from a quick visual assessment to know if closer examination is necessary.

Rayleigh waves—surface waves that carry energy along Earth's surface by elliptical particle motion, which appears on the surface as a ripple effect.

Recurrence interval—the actual or estimated length of time between two earthquakes in the same location.

Resonance—an increase in the amplitude (a measurement of wave size) in a physical system (such as a building) that occurs when the frequency of an applied oscillatory force (such as earthquake shaking) is close to the natural frequency of the system.

Retrofitting—making changes to a completed structure to meet needs that were not considered at the time it was built; in this case, to make it better able to withstand an earthquake.

Richter magnitude—the number that expresses the amount of energy released during an earthquake, as measured on a seismograph or a network of seismographs, using the scale developed by Charles Richter in 1935.

Rigid connections—connections that do not permit any motion of the structural elements relative to each other.

Rotation—turning from side to side.

Run-up elevation or height—the highest altitude above the tide line, in meters, that the water reaches as it is forced up on land by a tsunami.

S waves—secondary waves; waves that carry energy through the Earth in very complex patterns of transverse (crosswise) waves. These waves move more slowly than P waves (in which the ground moves parallel to the direction of the wave). In an earthquake S waves are usually bigger Ps.

Sag pond—a small body of water occupying an enclosed depression formed by fault movement.

Sand boil—a forcible ejection of sand and water from saturated soil, caused by strike–slip an earthquake or heavy flooding.

Saturated—having absorbed water to the point that all the spaces between the particles are filled, and no more water can enter.

Sediment—material that has been transported by wind, water, or ice and come to rest in a new location.

Sedimentary deposits—accumulations of small solid particles that originated from the weathering of rocks and that have been transported or deposited by wind, water, or ice.

Seismicity—earthquake activity.

Seismic—of or having to do with earthquakes.

Seismic sea wave—a tsunami generated by an undersea earthquake.

Seismic zone—a region in which earthquakes are known to occur.

Seismogram—the record of earthquake ground motion recorded by a seismograph.

Seismograph—an instrument that records vibrations of the Earth, especially earthquakes.

Seismograph station—a site at which an array of sesimographs is set up and routinely monitored.

Seismology—the scientific study of earthquakes.

Shaking—rapid horizontal vibration of the base of the model, simulating an earthquake. In an actual earthquake, of course, shaking occurs in many directions.

Shear force—force that acts horizontally (laterally) on a wall. These forces can be caused by earthquakes and by wind, among other things. Different parts of a wall experience different shear forces.

Shear walls—walls added to a structure to carry horizontal (shear) forces. These are usually solid elements, and are not necessarily designed to carry the structure's vertical load.

Sill plate—the structural member at the base of a wood frame building that joins the building to its reinforced concrete foundation.

Slump—a type of landslide in which a block of rock or soil moves along a curved surface and rotates.

Soft stories—stories in a building, usually lower stories with many openings, that are poorly supported or braced, and hence vulnerable to collapse.

Stick-slip movement—a jerky, sliding movement along a surface. It occurs when friction between the two sides of a fault keeps them from sliding smoothly, so that stress is built up over time and then suddenly released.

Strata (s. *stratum*)—layers of rock or other materials formed at different periods in geologic time.

Strike-slip faulting—fault movement in which the fault is horizontal.

Structural elements or structural features—a general term for all the essential, non-decorative parts of a building that contribute structural strength. These include the walls, vertical column supports, horizontal beams, connectors, and braces.

Studs—upright pieces in the outer or inner walls of a building to which panels, siding, laths, etc. are nailed or bolted.

Subduction—the process in which one lithospheric plate is forced down under another plate and drawn back into the Earth's mantle.

Surface waves—waves that move over the Earth at its surface. Rayleigh waves and Love waves are surface waves.

Topography *(adj. topographic)*—the shape of the land; the contours and the arrangement of surface features that characterize a region.

Torsion—twisting or turning. A building must be resistant to extreme torsion to resist earthquake damage.

Transverse waves—waves that vibrate particles in a direction perpendicular to the wave's direction of motion (S waves).

Triangulation—using data from three or more known points to locate an unknown point, in this case, the epicenter of an earthquake.

Tsunami—a potentially destructive ocean wave created by an earthquake or other large-scale disturbance of the ocean floor; a seismic sea wave. This Japanese word has the same form in both the singular and the plural.

Unconsolidated—loosely arranged, not cemented together, so particles separate easily.

Unreinforced masonry—brick, stone, or adobe walls without any steel reinforcing rods or other type of reinforcement. Buildings of this type were probably built before 1940.

Variable—in a scientific experiment, the one element that is altered to test the effect on the rest of the system.

Veneer—an outside wall facing of brick, stone, or other facing materials that provides a decorative surface but is not load-bearing.

Vertical load—the effect of vertical force (gravity) acting on the elements of a structure.

Wave height—the vertical distance from a wave's crest to its trough. (This measurement will be twice the amplitude measured for the same wave.)

Wave crest—the highest point a wave reaches. The lowest point is called its *trough.*

Wavelength—the horizontal distance between two successive crests, often measured in meters.

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