

LEVEL: Grades 9-12

SUBJECTS: Career Education, Earth Science, Environmental Education, Science, Sociology.

PROCESS: Through role playing various career persons and community residents, students embark on a challenging simulation in which they develop solutions that must balance water needs, environmental issues, economics, and other societal values.

OBJECTIVES: The student will:

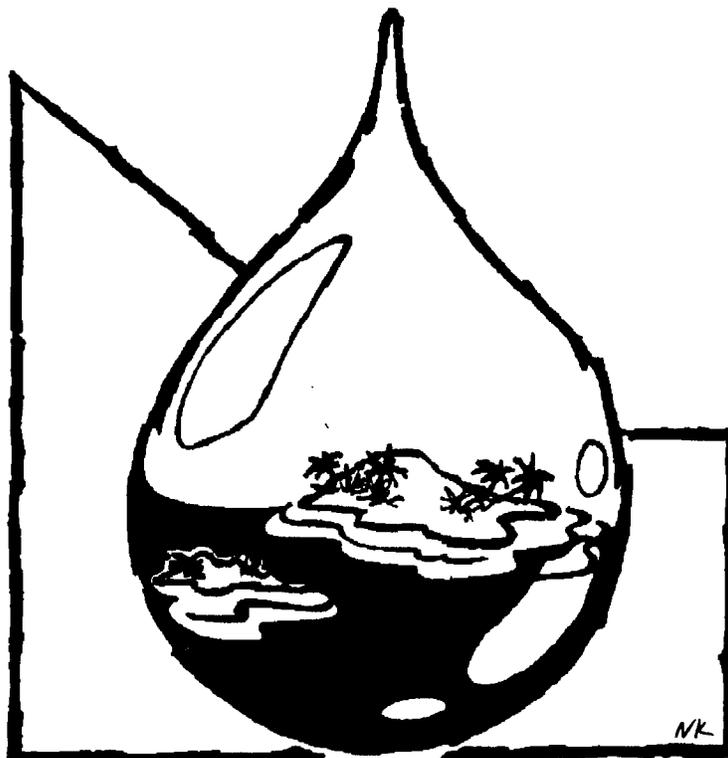
1. Identify factors that impact water-use decisions.
2. Role play various water-resource careers.
3. Identify the interaction necessary between the disciplines to make water-resource decisions.
4. Identify additional information needed to make a water-resource decision.
5. Recognize the difficulty in making resource decisions for a community.

TIMEFRAME: Two to three 45-minute sessions.

SKILLS: Analyzing, applying, comprehending, debating, describing, discussing, evaluating, listening, listing, problem solving, role playing, understanding cause and effect, valuing.

MATERIALS: Poster paper, markers, calculators, "Blue Lagoon Island Fact Sheet" (attached), specific career information (attached), "Background Notes: The Maldiv Islands" (attached), maps of the island for general public (attached).

VOCABULARY: Archaeology, desalting plant, fault, hydrology, limnology, scouring, spawning.



MAYHEM IN THE MALDIVES

OVERVIEW: Water is a limited and precious natural resource. All living organisms depend on it. Decisions regarding water resources for a community are complex and require expertise in many different technical disciplines. Some factors to consider include:

1. The location from which water will come.
2. The amount needed.
3. The quality of the water.
4. The method of transportation.
5. The users of the water.

In addition to technical disciplines, public interest must be considered in making decisions. Professional and public groups must work together to find the best solutions based on their resources and priorities. Solutions must balance water needs, environmen-

tal issues, economics, and other societal values, such as how the solution affects the current way of life.

In this activity students engage in a simulation about water use decisions. Every student or group of students role plays a specific water-resource career and is given at least one piece of information that no one else has. Students need to take into account specific factors such as endangered plants and fish, faults, archaeological sites, economics, and changes to their lifestyles as they make decisions regarding this water use situation. Some of the background information for this simulation is based on the Republic of the Maldives, a chain of islands in the Indian Ocean.

PROCEDURE:

PRE-ACTIVITY:

1. Photocopy the maps, background information on the Maldiv Islands, and the informa-

tion for each of the careers.

2. Cut apart the pages with two careers so each career person or pair is given only one career.

ACTIVITY:

1. Read the following instructions to all students:

You and your classmates live on Blue Lagoon Island, a fictional island located in the Maldives. The Maldives are located in the Indian Ocean, southwest of India. Some of you are members of the Blue Lagoon Island Village Council. At this week's Council meeting, the manager for the fish cannery is presenting a proposal that involves the expansion of the cannery. The expansion requires the cannery to use a larger percentage of the island's domestic water supply. In addition to many villagers and elders in attendance, there are also representatives who are employed on the island, including an archaeologist, fishery biologist, general biologist, civil engineer, economist, farmer, geologist, hydraulic engineer, hydrologist, limnologist, mechanical engineer, social science analyst, tourist board member, and water treatment plant manager. Each person has been invited to speak and assist the Council in making a decision that is in the best interest of Blue Lagoon Island.

After hearing all the concerns, the Council works to reach a consensus on the cannery's proposal. Each member of the Council has one vote.

2. Choose one student (or a pair of students, if the group is large) to represent each of the career roles listed in number 1. Choose one student to represent the fish cannery manager, two or three students to represent the village elders, two to three students to represent the young villagers, five to seven students to represent the Council members, and a Council leader.

3. Give each student or pair of students a map of the island, background notes on the Maldives, and information on their specific roles. Note the archaeologist and geologist each have a different map than the general map of the island.

4. Give students time to read the materials and prepare for the Council meeting. Have students prepare name plates for their roles so members of the Council know their job titles or areas of interest.

A. *CAREER ROLES, THE FISH CANNERY MANAGER AND VILLAGERS* should make strong cases for their positions concerning this water issue.

B. *COUNCIL LEADER AND COUNCIL MEMBERS* Council members review all the information, list the questions they may have about the project, and decide on a process for making a decision about the proposed expansion of the fish cannery. Each Council member should have a copy of the questions and be prepared to ask presenters about their concerns.

5. The Council leader asks the fish cannery manager to make a presentation to the group first.

6. The Council leader asks Council members to identify possible solutions or alternatives to get extra water to the cannery.

7. The Council leader calls on each career person to make a presentation at the Council meeting. Each career person has information that none of the other careers has and has a concern to present. The Council leader lists the advantages and disadvantages of each position, writing them down as the career person speaks.

8. Village elders and youth are invited to speak about the issue from their own perspectives.

9. After all the Council leaders have made their presentations, the Council members take the issue back into their own hands to discuss, evaluate pros and cons, and decide whether to accept, reject, or modify the fish manager's proposal. The Council leader announces the decision.

10. If there is no consensus on a decision, identify the reasons why consensus was not possible.

11. What additional information was needed to make a decision and how would that

information be obtained?

POSSIBLE ALTERNATIVES

1. Build a dam at the lake and install a pipeline to convey the water to the cannery.
2. Build a dam at the lake and build a canal to convey the water to the cannery.
3. Build a desalting plant and conveyance system next to the cannery and use the desalted water at the cannery.
4. Automate the cannery equipment.
5. Utilize the water supply from the Blue River Water Treatment Plant and convey to the cannery via pipeline or canal.
6. Reject the cannery manager's proposal--no action to be taken.

ASSESSMENT:

1. Have students identify with whom (discipline) they needed to interact in order to address their concerns. For example, the fishery biologist needed to work with the hydraulic engineer and civil engineer to take care of the spawning concern.
2. Have students each write a paragraph stating what his or her own decision would have been in regard to the cannery request and why.

EXTENSIONS:

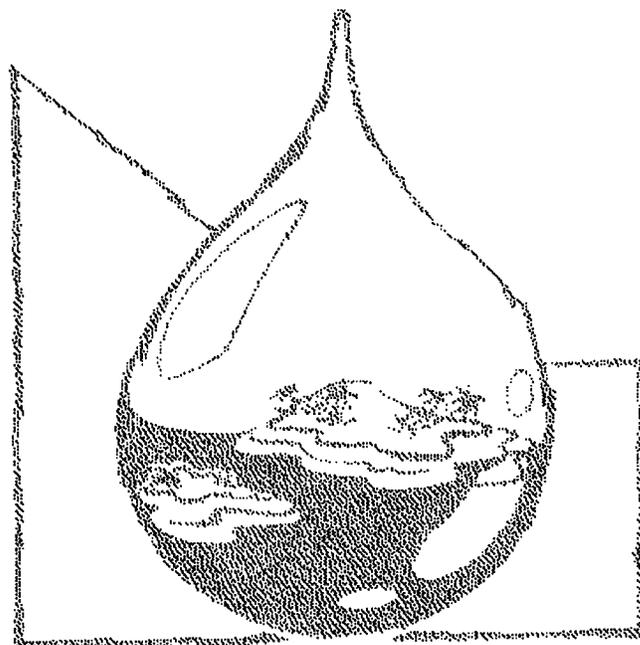
1. Have the students diagram the interaction using lines or arrows to show (1) information needed between disciplines; (2) disciplines in agreement; and (3) disciplines in disagreement.
2. Add additional players, such as government agencies, that would be involved in enforcing environmental laws.
3. Ask students to identify one of the careers that appealed to them as a potential career. Have them bring in a speaker to expand on their career or ask them to research educational requirements and/or where a person with this career might find employment.

RESOURCES:

Working in Reclamation. Saving the Water, Saving the Land for the People, U.S. Department of the Interior, Bureau of Reclamation, brochure.

Engineering Careers, U.S. Department of the Interior, Bureau of Reclamation, brochure.

CREDIT: US Bureau of Reclamation and the Denver Earth Science Project contributed to this lesson.



BLUE LAGOON ISLAND FACT SHEET

General Information for each Person at the Council Meeting

Blue Lagoon Island has been inhabited for the past 300 years by a small group of people who originally came from the mainland. The villagers have a simple lifestyle. Many of them have never left the island. Historically, the villagers have farmed and/or fished for food.

The island has recently become an ideal site for small business ventures. Over two years ago, a hotel franchise built a small resort. A fish cannery was established on the island five years ago.

- o Current population of the island is 1,000.
- o 600 people are unemployed and they are either over 65 or under 18 years of age.
- o 400 people are employable with 360 currently employed.
- o 200 of those employed work at the fish cannery. The other 160 people work at the resort or the water treatment plants.
- o If the expansion of the cannery is approved, 40 unemployed villagers could be hired at the cannery. An additional 160 people from the mainland could be employed.

BACKGROUND NOTES: THE MALDIVES ISLANDS

(Modified from the United States Department of State, Bureau of Public Affairs Bulletin, *Background Notes: Maldives*, February 1990.)

OFFICIAL NAME: Republic of Maldives

GEOGRAPHY:

- Area: 298 square kilometers (115 square miles)
- 1,200 islands, 202 acres inhabited
- Capital: Male
- Terrain: flat islands
- Climate: hot and humid
- Location: Indian Ocean

ECONOMY:

- Domestic economy: tourism (17%); fishing (16%); agriculture (11%); and industry (6%)

- Exports: \$35 million (fish products, garments)
- Major export markets: United States, Thailand, Sri Lanka
- Major fish sold: skipjack and yellowfin tuna
- Imports: \$74 million (manufactured goods, machinery, equipment, food products)
- Major import suppliers: Singapore, Thailand, India
- First resort: 1972
- Current number of resorts on the islands: 58

GOVERNMENT:

- Republic: Constitution June 4, 1964
- Independence: July 26, 1965
- Branches of government: executive, legislative, and judicial
- Political parties: none
- Suffrage: universal adult

CLIMATE:

- Equatorial; hot and humid
- Average temperature: 27°C (80°F)
- Relative humidity: 80%
- "Wet" southwest monsoon (May-October)
- "Dry" northwest monsoon (December-March)
- Average annual rainfall: 254 centimeters (100 inches) in the north; 281 centimeters (150 inches) in the south
- Absence of potable water in most places

PEOPLE:

- Population: 52,000
- Ancient religion: Buddhism
- Official religion today: Islam
- Official language: Dhivehi (Indo-European language related to Sinhala, the language of Sri Lanka)
- Writing system: right to left (like Arabic)

ARCHAEOLOGIST

You are a scientist who studies the life and culture of past (ancient) peoples through excavations, artifacts, etc. Though Blue Lagoon Island is small and has a relatively small population even today, it has been inhabited during various time periods for the past few hundred years.

During the past few years, you have begun to excavate various sites where ancient peoples inhabited the island. You have already excavated a number of dwellings and worship sites from the 12th-century Buddhist civilization. You and your teammates have found pottery (broken pieces and a few entire pots), tools, pieces of fabric, Buddhist worship idols, and wood and stone fragments that outline the ancient dwellings used by the previous inhabitants.

CONCERN

The 12th-century Buddhist artifacts are located immediately south of the village (see map). Expanding the village southward to accommodate the additional cannery workers would destroy these relics. You are opposed to the expansion of the cannery.

FISHERY BIOLOGIST

You are a scientist who investigates fisheries-related problems, including fish habitat improvement, fisheries protection, and enhancement measures. You work with both native and non-native fish.

CONCERN

An endangered fish spawns in the South River. These fish require clean materials (gravel, rock, cobble) for spawning (reproduction). Sediment collects on the materials through the year but is flushed out with the rainy season flows, keeping the river bottom clean. The minimum flushing flow is 80,000 gallons a day for two weeks. If this flow is not achieved, spawning will not be successful for that year. Constructing a dam to an elevation of 80 feet would reduce or stop the flows that provide this scouring action. As a result, the substrate would become clogged with silt, and the fish would have no area in which to lay their eggs.

You are also concerned about the change in water temperature and dissolved oxygen content since these changes affect the endangered fish and the other native fish.

Fishery protection would be needed in areas where canals or pipelines withdraw water from the lake or from the rivers. That protection could consist of screens on the intake structures or barriers of some type to prevent the fish from getting out of the waters where they naturally occur. In addition, young fish may be at risk of being eaten by other species (predators) that reside around the pump intake structures. These predators eat enough of some species to threaten their already depressed population.

GENERAL BIOLOGIST

You are a scientist that deals with the origin, history, physical characteristics, life processes, and habits of plants and animals. You are concerned with the impact to the environment when the natural surroundings are changed.

CONCERN

A rare plant that grows around the lake at an elevation of 40 feet is on the endangered species list. If a dam were built at the lake to store more water, the plants would be flooded and die. In addition, wetlands are located along the South River, and you want to see them protected.

COUNCIL MEMBERS

You have been elected to the Blue Lagoon Island Village Council because you are perceived to be a fair and wise member of the community. Your job is to represent all people (present and future) and do what is in the best interest of the island.

CONCERN

You must be open minded and give each person a chance to present his or her viewpoint on the proposed fish cannery expansion. Keep in mind that potable water is a scarce and valuable resource on your island. Your main task is to look over the information about the island and decide what else you need to know to make a good decision.

CIVIL ENGINEER

Civil engineering is the branch of engineering that deals with the design and construction of dams, highways, bridges, tunnels, waterworks, structures, etc. Before these structures can be built, survey crews determine the geologic structure in the area. Raw materials needed for construction, such as gravel and sand to make concrete, are ordered and delivered to the construction site. Land owners in the vicinity of the new construction are contacted for permission to allow workers on or near their land. If the structure is to be built on land not owned by the government, purchase of the land is required before construction can begin.

CONCERN

As a civil engineer, you know that all raw materials for the cannery expansion must be imported to the island. Sand and gravel, averaging \$8 per ton, can be brought to the island. You estimate that 3,500 tons of sand and gravel will be needed to expand the cannery.

All of the heavy construction equipment must also be brought to the island. This not only adds considerable cost to the project, but it could also damage the roads that the heavy equipment and supplies must be driven over. The roads were not built to carry heavy loads.

For the dam alternative, an outlet works would have to be designed that would meet the flushing flow requirement of 80,000 gallons a day so the fish can spawn.

The canal and pipeline alternatives would require construction of fish screens to keep the fish out of the pump intake structure.

ECONOMIST

You are a specialist in the science that deals with the production, distribution, and consumption of wealth, and with the various related problems of labor, finance, and taxation. You help companies predict what products are wanted by the people, and help establish production and distribution systems that will get the products to the consumers. You help companies look at the costs of raw materials, labor, buildings, and taxes. You advise them on how to spend and invest their profits.

CONCERN

The cost to build either a pipeline or canal to the cannery from the treatment plant or the lake is about \$1 million a mile. The cost for fish screens would have to be added to this cost. The stronger the pump intake structures, the greater the cost for the fish screens.

The cost of building a dam at the lake to an elevation of 80 feet would be \$5 million.

Desalting sea water is about \$3.50 per 1000 gallons. 50,000 gallons per day would cost \$175 a day or \$63,875 a year. The cost to convey the desalted water is 1% of the project cost. It would cost about \$10 per gallon to build the desalting plant.

FARMER

You represent the agricultural community for the island. Dominant crops include fruit trees and coconut palms.

CONCERN

Agriculture provides 11% of the income to the island. You do not want to see water taken away from agriculture in order to provide water for the expansion of the cannery. As far as you are concerned, agriculture is just as important as the cannery.

You and the other farmers are willing to support expansion of the cannery as long as the water does not come from agriculture.

GEOLOGIST

You are a specialist in the science that deals with the physical nature and history of the earth. This includes the structure and development of its crust, the composition of its interior, individual rock types, fossils, and ground movement along faults. You also study fossils embedded in the rocks to learn about the past climate and organisms inhabiting continents and oceans. Besides studying the basic rock make-up of the earth, you study faults and volcanic activity on Blue Lagoon Island and other islands that make up the Maldives.

CONCERN

There is an active fault between the current cannery and the lake (see map). A fault is a fracture (break, crack, split) or zone of fractures in layers of rock together with movement that displaces the sides relative to one another. A canal or pipeline to carry water from the lake or from the Blue River Treatment Plant to the expanded cannery would be potentially dangerous since it would have to cross the active fault. An earthquake along the fault after such a canal or pipeline is built could potentially cause great destruction as the flood water flows to low lying regions. The fault also makes it undesirable to expand the village to the north to accommodate new employees and their families moving to the island.

HYDRAULIC ENGINEER

Hydraulic engineering is the branch of civil engineering that deals with the physics of the movement of water and the affected structures of channels. You would help in designing outlet works from the dam and intake structures for the canal or pipeline.

CONCERN

An endangered fish spawns in the South River. These fish require clean materials for spawning (reproduction). Sediment collects on the materials through the year but is flushed out with the rainy season flows.

Building the dam to an elevation of 80 feet will reduce the river flow and only allow flows of 50,000 gallons per day.

LIMNOLOGIST

Limnology is the field of science that studies fresh water ecosystems including water quality (chemical), sediments (physical), and the food chain (biological). You are involved in the collection of water and sediment samples and analyzing them to make sure specific water quality standards are met.

CONCERN

Making the lake deeper can change the temperature of the lake, the dissolved oxygen content, and the productivity (food for fish). These changes could reduce the number of native fish in the lake and/or create habitat that would be more suitable for non-native species that would out-compete the native species. Flooding areas that were not previously under water could also change the productivity of the entire lake.

HYDROLOGIST

You are a scientist who deals with the waters of the earth, their distribution on the surface and underground, and the cycle involving evaporation, precipitation, and flow to the seas. You are concerned with the water level in aquifers and the flow of water in rivers and lakes since all plants, animals, and people depend on one of these sources for freshwater. Islands such as Blue Lagoon often have a limited amount of freshwater because the precipitation runs quickly off the land into the ocean.

CONCERN

The island has a dry season (six months long) and a rainy season (six months long). Rainfall on the island flows to the ocean as follows:

*Blue River: Rainy season = 350,000 gallons per day
Dry season = 200,000 gallons per day

*East River: Rainy season = 100,000 gallons per day
Dry season = 75,000 gallons per day

*South River: Rainy season = 100,000 gallons per day flows into the lake and down to the ocean via the South River

Dry season = Flow into the lake drops to 25,000 gallons per day

When the lake level gets to 60 feet, the South River begins flowing at 50,000 gallons per day. For the lake to supply 50,000 gallons per day during the dry season would require raising the lake level to an elevation of 80 feet by building a dam on the South River.

FISH CANNERY MANAGER

You are proposing the expansion of the cannery. The cannery processes tuna that is "dolphin free." With the recent dolphin-free awareness in the United States, there is great potential in the U.S. tuna market. Processing tuna in a cannery requires large quantities of water. Additional water is needed if the cannery is to expand. A larger cannery would increase jobs and lift the economy.

CONCERN

Current cannery: Processes 5,000 pounds a day

Requires 10 gallons water per pound of tuna (50,000 gallons per day)

Employs 200 people

Proposed Expansion (Doubling Plant Size)

Cost of expansion = \$10 million

Requires an additional 50,000 gallons of water a day

Would employ an extra 200 people

Since the cannery is currently using the entire dry season flow of the East River, extra water could come from the Blue River Treatment Plant, which has extra capacity. The cost to get water from the Blue River Treatment Plant to the cannery is not included in the \$10 million. You assume the Village Council will pay for it because of the increased revenue your expansion will bring to the island.

MECHANICAL ENGINEER

Mechanical engineering is the branch of engineering that deals with the design, operation, and production of machinery and mechanical systems. You help design new and more efficient machines for production and assembly lines in large companies.

CONCERN

As a mechanical engineer, you know that another option to expanding the cannery is to automate the machinery. Rather than do all the fish processing by hand, you suggest that the addition of specialized machines would help speed up the processing of fish. This type of modernization costs twice what the expansion would, but it requires less water and fewer additional workers.

Alternative Cannery Process -

Cost to double plant output = \$20 million

Water usage cut from 10 gallons per pound of tuna to 7 gallons per pound (total of 70,000 gallons per day)

Total employment = 300

SOCIAL SCIENCE ANALYST

You are a specialist who examines how change impacts the lives of people living in a region. You want to know how new businesses, jobs, construction, people, and products affect an existing community.

CONCERN

As the social analyst, you are concerned about how the people of the village will be impacted if a social change occurs. If there is a large influx of people from the mainland, will the customs and traditions of the native islanders be lost? How could this affect future generations if their heritage is not preserved? Can the 160 additional workers commute by ferry back and forth from the mainland instead of living on the island?

TOURIST BOARD MEMBER

As a representative of the island tourist businesses, you would like to see the local resort expanded. You are responsible for bringing tourists to the island for vacations. Since the resort was built two years ago, tourists have eagerly visited the island because it offers rare beauty in a relatively isolated setting. The island offers tourists a wonderful, quiet get-away with many unique historical and cultural attractions like the 12th-century Buddhist artifacts, waterfalls on the Inner River, the Blue Lagoon, and the lush tropical vegetation.

CONCERN

Expanding the resort would compete with the additional water needed by the cannery. Also, the 12th-century Buddhist artifacts and the beauty of the natural waterfalls, found on the Inner River, are crucial to attracting visitors to the island. It has become evident in the last few years that more and more tourists want a vacation that is unique and away from regular tourist crowds.

Sport fishing could be impacted by the dam alternative if flushing flows are not adequate to provide for spawning.

You propose the expansion of the resort at a cost of \$10 million rather than the expansion of the fish cannery to boost the economy of Blue Lagoon Island. Tourism currently brings \$7 million to the island annually (on the average 100 guests are on the island every day). The resort could easily be expanded to accommodate 200 guests a day.

WATER TREATMENT MANAGER FOR BOTH PLANTS

As plant manager for both the Blue River and East River Water Treatment Plants, you are responsible for providing an adequate, clean water supply to the people living on Blue Lagoon Island. As part of your job, you investigate the available water supplies and determine the quantity of water being used by each resident living on the island. In addition, you must be able to supply enough clean water to businesses such as the cannery and resort.

CONCERN

The water supply system is adequate now, but there will not be enough water if the number of people increases or if the cannery requires more water.

Each villager requires 150 gallons of water a day. The resort averages about 100 guests a day who require 150 gallons of water a day.

The village and resort receive all of their water from Blue River Treatment Plant: 165,000 gallons per day (Capacity = 215,000 gallons per day).

The cannery receives 50,000 gallons per day from East River Treatment Plant. This is the plant's full capacity.

If the cannery expands as proposed, it will require an additional 50,000 gallons per day (the entire extra capacity of the Blue River Treatment Plant). The 160 new villagers will require an additional 24,000 gallons per day. They will require even more water if each of those new villagers has a family.

VILLAGER ELDERS

You represent the local village and its community. You have lived your entire life on Blue Lagoon Island and want to see the island continue as your quiet beautiful home. You continue to carry on the customs begun by earlier generations of island people.

CONCERN

The elders are opposed to the fishery expansion. You believe it will alter the current way of life, create more pollution, and destroy part of the natural rainforest so important to the island people. You are concerned about the political power shifting if many people from the mainland move to the island.

YOUNG VILLAGERS

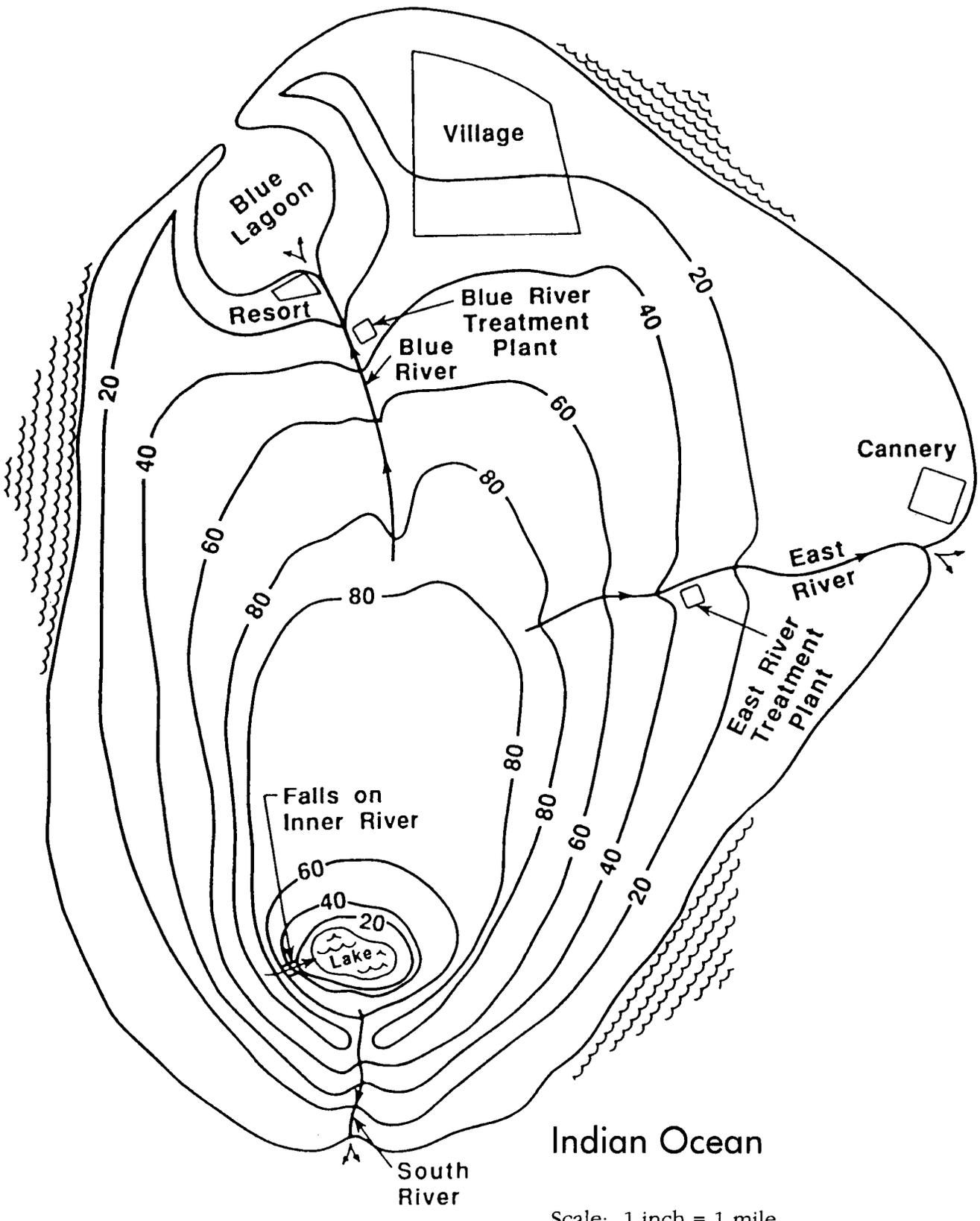
You represent the young people living on Blue Lagoon Island. Although you respect the wishes of the elders and abide by many of the old customs, you realize that change is taking place on the island and throughout the world. You have been introduced to modern electronic equipment such as radios, TVs, and compact disc players through tourists you have met visiting the island. You want modern appliances (refrigerators, stoves, etc.) for your family.

CONCERN

You are definitely in favor of the expansion of the cannery or the resort. You realize that either expansion will result in more jobs on the island. More and better paying jobs are needed by the young people who will be the future leaders of the island.

You are concerned about outsiders from the mainland coming to the island for these new jobs. You want control of the island to remain in the hands of local villagers. Like the elders, you do not want to see a shift in political power to outsiders. You are committed to supporting the island if new jobs are provided.

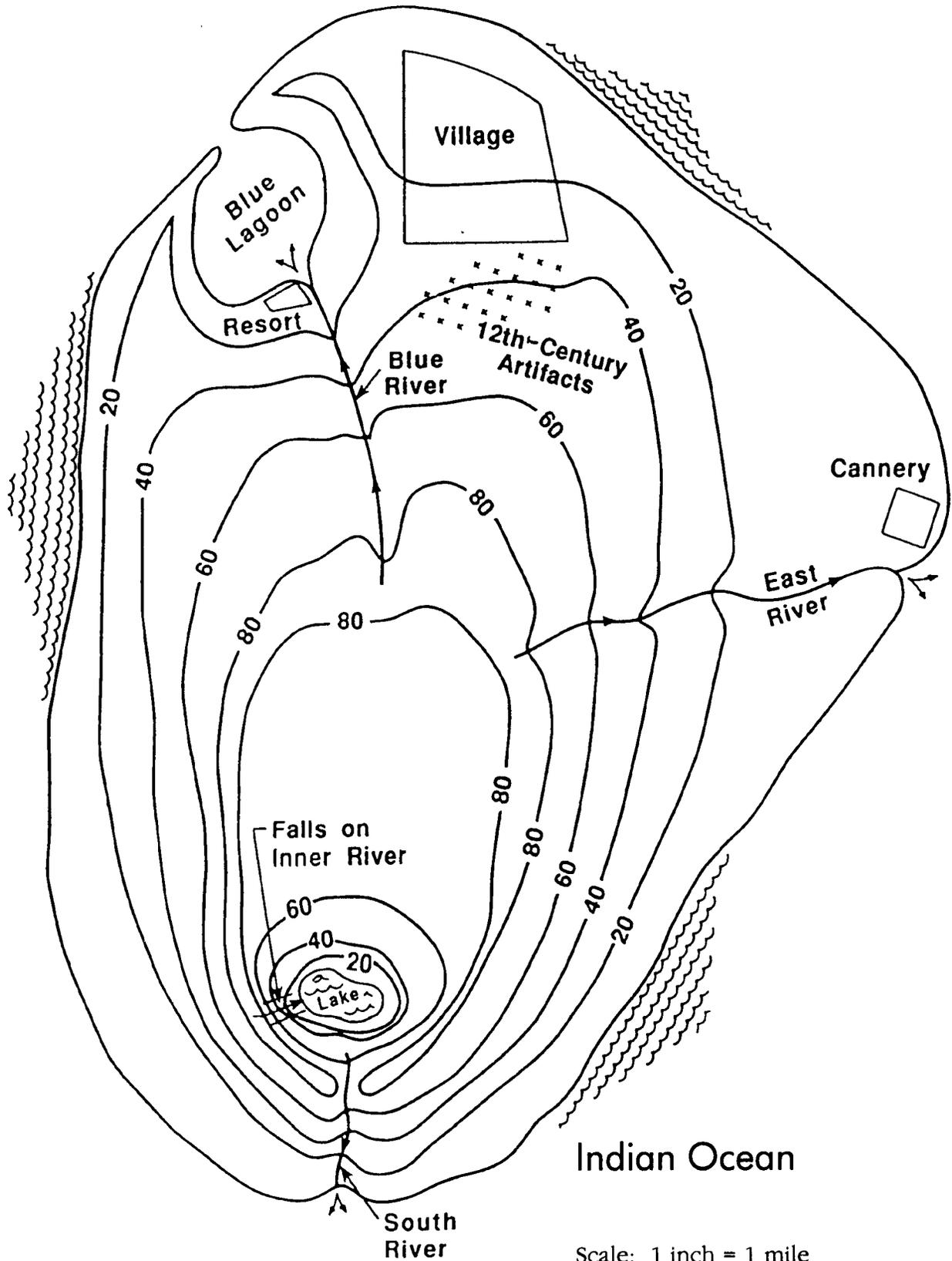
BLUE LAGOON ISLAND (For All)



Indian Ocean

Scale: 1 inch = 1 mile

BLUE LAGOON ISLAND (For Archaeologists)

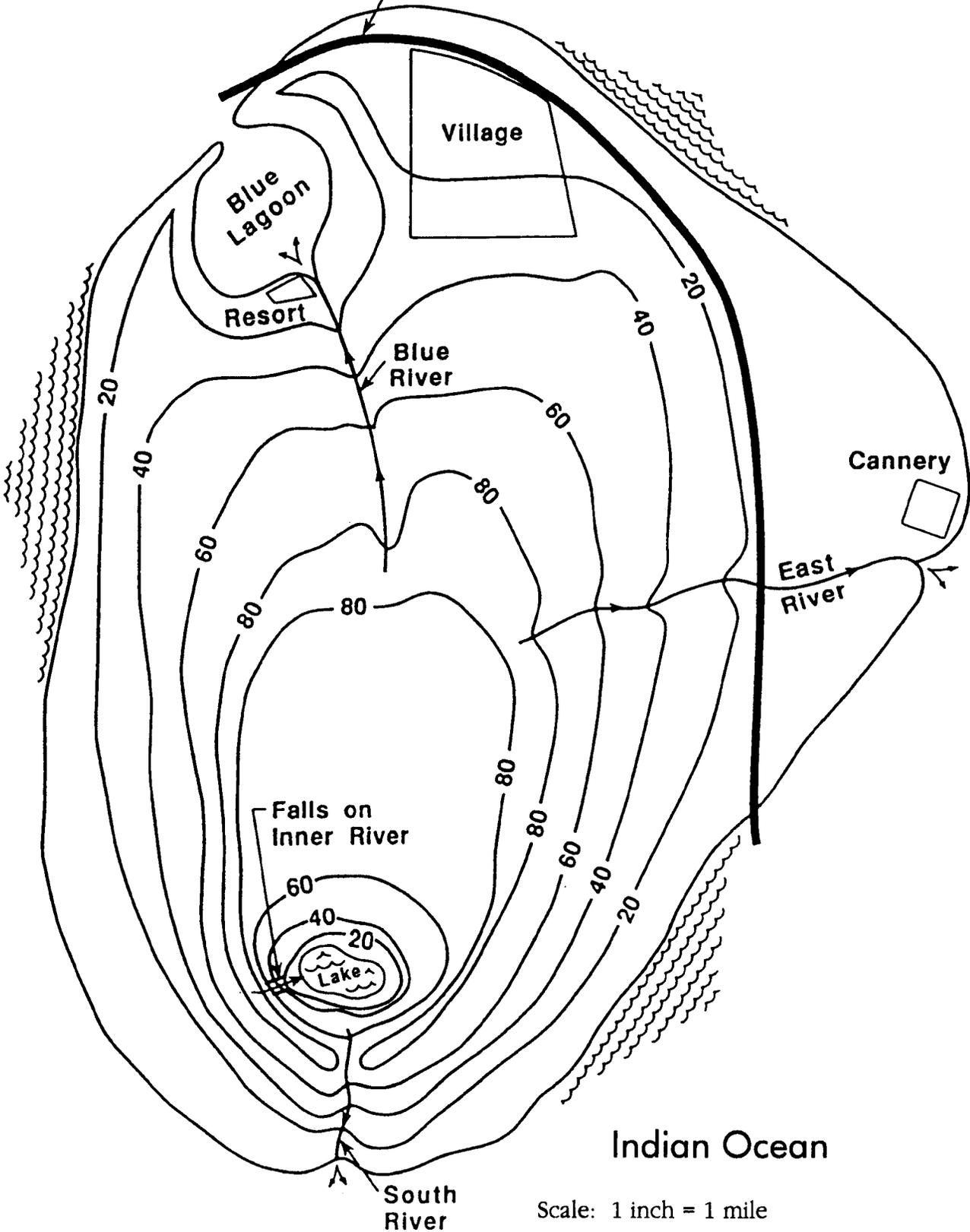


Indian Ocean

Scale: 1 inch = 1 mile

BLUE LAGOON ISLAND (For Geologists)

Active Fault:
Earthquakes are likely



Scale: 1 inch = 1 mile