ESTUARY DEVELOPMENT WITH IMPLICATIONS FOR MANAGEMENT: A CASE STUDY OF NORTHWEST NATURAL GAS COMPANY'S LIQUIFIED NATURAL GAS (LNG) PROJECT AT YAQUINA BAY, OREGON

by

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November, 1975

[illegible] and opinions expressed herein are solely those of the author [illegible] necessarily reflect the views of Oregon State University or [illegible] of Oceanography)

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INTRODUCTION AND SCOPE

In 1973, Northwest Natural Gas Company embarked on a project to import liquified natural gas (LNG) via ocean transport from Alaska to Oregon. Yaquina Bay, chosen as the primary site for the LNG import terminal, is the smallest of Oregon's coastal deep-water ports. The project is a significant addition to the port and provides new justification for maintenance of its deep-water status. The project also has potential for induced economic development which adds to its attractiveness for the region.

This case study is an analysis and evaluation of the project in terms of its environmental and economic impacts. The assumption is made that while no LNG supply is presently available, eventually the facility will be operated as an import terminal for ocean-transported liquified natural gas.

Section 1 provides background information on project status, LNG itself, and Yaquina Bay. The portions on Yaquina Bay include a discussion of factors which relate to the ecology of the estuary as well as details on present and planned use patterns in the area. This material is provided as reference information for the economic, environmental and management analyses which follow and is not directly related to the evaluation of the LNG project.

Section 2 looks at economic impacts in both subjective and quantitative ways. A discussion of potential induced development is provided and several development scenarios evaluated using a Yaquina Bay region economic input-output model.

Section 3 evaluates environmental impact assessments and discusses some areas in more detail. Water quality, land use, hazard and induced impacts are reevaluated.

The final section is an analysis of the environmental management regime and suggests some options for improvement of the process of estuary management. The need to provide a mechanism to link project and regional planning is discussed, along with various potential specific estuary management tools.

SECTION 1

THE YAQUINA BAY LNG PROJECT

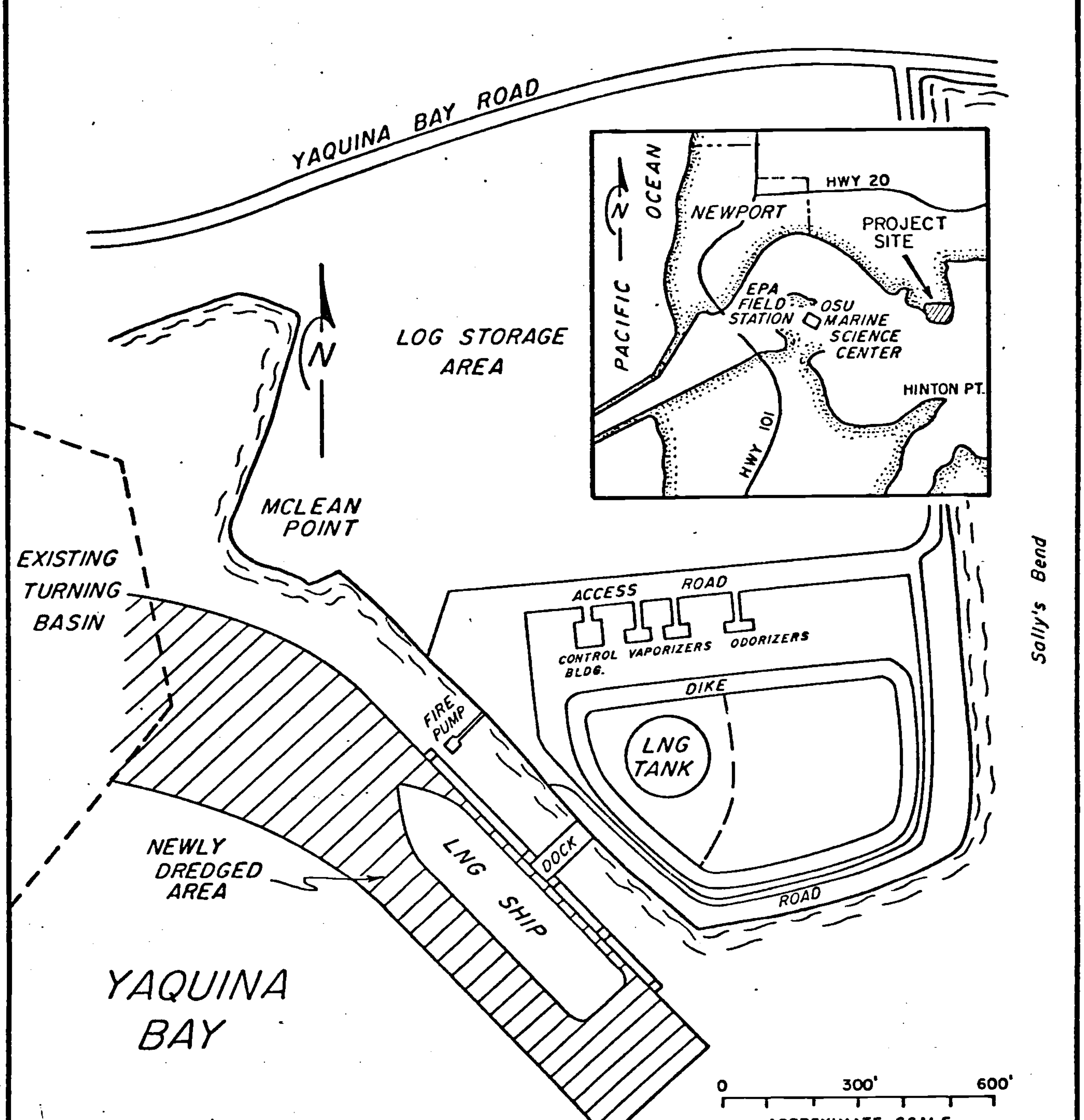
The Project

In January 1974, Northwest Natural Gas Company (Northwest Natural) entered into a 10-year renewable agreement with Phillips Petroleum Company (Phillips) and Marathon Oil Company (Marathon) to purchase liquified natural gas (LNG) from their plant at Nikiski, Kenai Peninsula, Alaska. Since that time the project has been in a tentative status due to extensive review by the Federal Power Commission (FPC). The most recent FPC decision concerning regulation and jurisdiction of the project has resulted in Phillips and Marathon withdrawing from the LNG sale agreement. The FPC decision on what role they must take in the project apparently makes it less attractive to sell LNG in interstate commerce (to Oregon) than to export the LNG to Japan (as they have been doing for several years under another contract) or just not sell it at all. However, Northwest Natural and the producers have not given up on getting Alaskan gas to Oregon and are attempting to get a more suitable jurisdictional arrangement through other means.

Northwest Natural had planned to import the gas via ocean transport for use within Oregon. A LNG receiving terminal is being constructed (see Figure 1) on the north shore of Yaquina Bay just east of Newport, Oregon. This facility is presently planned for use as a peak-shaving[1]

[1] A peak-shaving LNG plant liquifies natural gas on site during periods of low gas demand (summer), stores it, and revaporizes it to supplement gas supply during peak demand periods (winter). It is contrasted to a base load LNG plant which receives its supply of LNG from an external source (e.g. ship) and revaporizes it on a continuous output basis.

FIGURE 1 (adapted from: NWNG report, "Siting Consequences of LNG Import Terminal")



GENERAL ARRANGEMENT
NORTHWEST NATURAL COMPANY LNG RECEIVING TERMINAL
NEWPORT, OREGON

LNG plant, similar to that located in Portland just south of the St. John's Bridge. This will give the company flexibility and assure that supplemental gas will be available for the 1977-78 winter peak-load period, regardless of federal action. If a new LNG supply is obtained, the facilities will be modified by building the wharf and LNG unloading system. This modification will only take 8-10 months to complete, so conceivabley, if a LNG contract is renegotiated, the facility could go into operation as a marine LNG terminal and baseload plant when they open in Summer, 1977. Unless the FPC reverses its final decision or the producers accept required jurisdictional arrangements, this is unlikely.

If a new LNG supply is secured, be it from Alaska or elsewhere, ocean transportation is to be provided by an approved LNG ship constructed especially for this run. Estimated ship construction time will be 3 years from placement of order. In the interim, Northwest Natural has proposed that a foreign-built LNG carrier be chartered to transport the LNG (several are available). The interim proposal will require that Northwest Natural obtain a waiver or exemption from the 1936 Merchant Marine Act (Jones Act), which requires use of U.S. manned, registered and built ships for interstate ocean transport. This is needed since there are currently no U.S. built carriers.

Proposed Newport Facilities

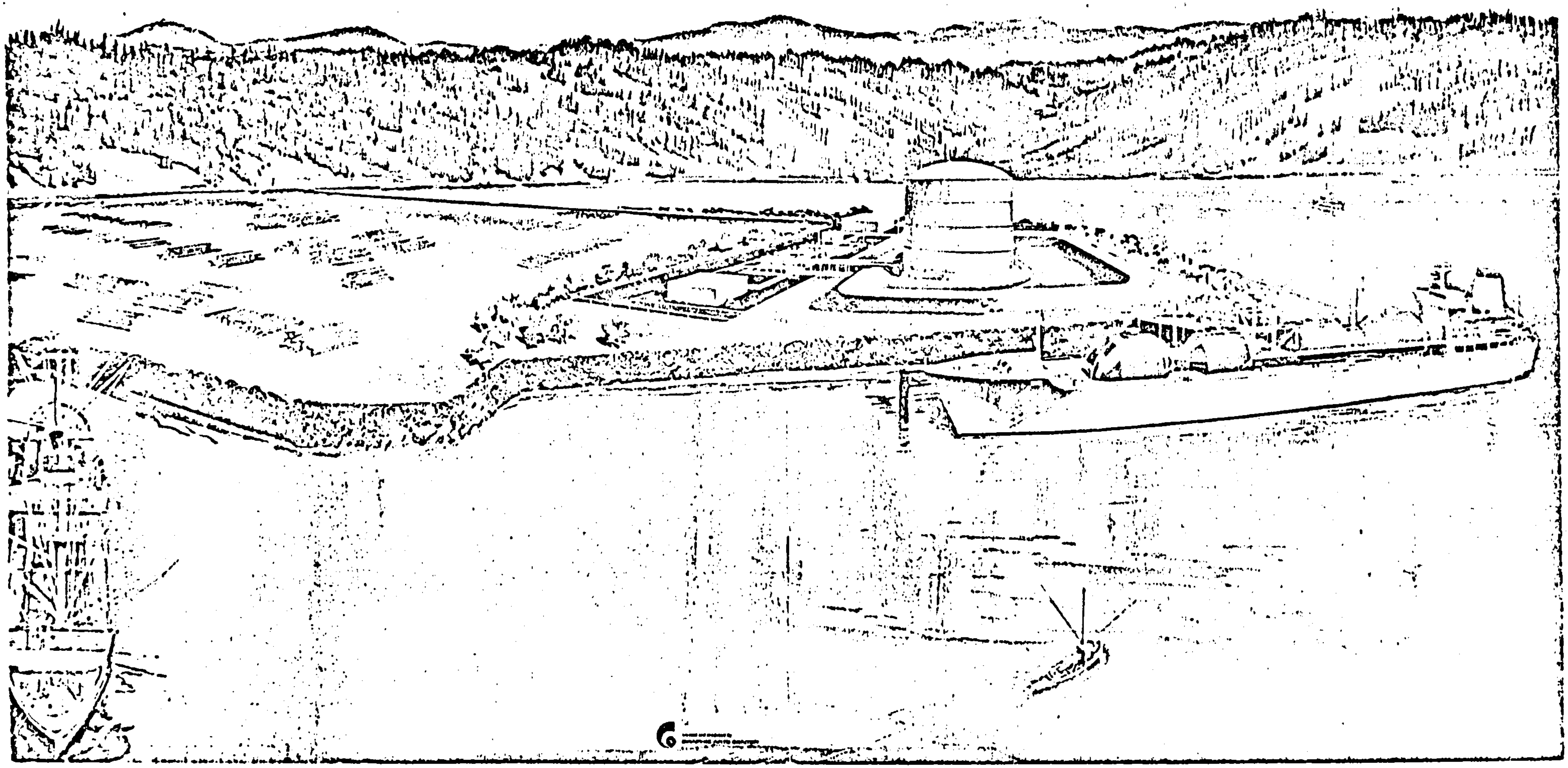
The Newport LNG terminal will be located on 21 acres of existing landfill on the north shore of Yaquina Bay, on a site known as McLean Point. This landfill was built up during the 1960's from Yaquina Bay and River dredge spoils. Figure 2 is an artist's rendition of the terminal.

1973 Annual Report

NORTHWEST NATURAL GAS COMPANY

Northwest Natural Gas Company

Artist's conception of the proposed LNG receiving, storage and vaporization facilities at Newport, Oregon to be constructed on a 20-acre site on Yaquina Bay. The storage tank will have a capacity of 300,000 barrels of LNG which will enable the Company to make a peak day delivery of 50 million cubic feet per day into its system.



Facilities to accommodate a 600 foot long LNG tanker will include a wharf large enough to dock and resupply the vessel, and a marine unloading system with insulated stainless steel pipelines, pumps and blowers. Dredging of the ship berth to a 30 foot depth was completed in May, 1974. Approximately 200,000 cu. yds. of spoil were removed to the adjacent property to aid in compacting the existing fill on which the LNG tank is being constructed.

The storage vessel to hold the LNG prior to vaporization will have a capacity of 300,000 barrels (42 U.S. gallons per barrel). The tank will be above ground, double walled with a domed roof, approximately 170 feet in diameter and 125 feet in height. The outer tank will be carbon steel, the inner tank will be 9% nickel-steel with ground glass bottom insulation and an expanded perlite side space insulation. Top insulation will be mineral wool. The operating pressure will be a 3 psig maximum at a temperature of minus 259°F. The daily boil-off rate will be 0.7% of full tank volume. LNG boil-off will be sent into the pipeline system thus avoiding any flaring of gas to the atmosphere.

If the LNG facility goes into operation as a peak-shaving plant, natural gas coming into Newport from the Northwest Natural distribution system will be liquified on-site. Toward this end, Northwest Natural has ordered a liquifaction unit for installation at Newport. Liquifaction of incoming gas will take place during the summer and revaporization will occur during winter peak-demand periods.

Design calls for vaporization to be accomplished by burning approximately 1% of the natural gas vaporized. Part of this loss may be recoverable through a heat exchange process, if plans materialize to construct associated industries to utilize the cold energy in the LNG. Operating as a peak-shaving plant, the cold energy will only be available in winter, and even then only periodically as demand fluctuates. The vaporized gas will be delivered into Northwest Natural's distribution system via a new 7 mile pipeline connection to an existing 12 inch gas main at Toledo.

The LNG from Alaska would have increased Northwest Natural's gas supply by 15%, with a capacity to deliver 30-50 million cu. ft. (MMcF) per day of natural gas.

Current Status of Project

Original projections called for Alaskan LNG delivery to commence by 1 January, 1975. Initial LNG deliveries were to be made at the existing Portland LNG peak-shaving plant, which was to be modified to receive LNG tankers. The initial delivery date was successively moved back. Even if acceptable jurisdictional arrangements were made and the Alaskan LNG contract renegotiated, it would be unlikely that LNG could be received before the completion of the Newport facilities in Summer, 1977. Site preparation at Newport started in July, 1975 and actual tank construction will begin about January, 1976.

State and local permits for the originally visioned project have been obtained. As noted earlier, a long delay occurred in getting a final ruling on the project by the FPC. The initial decision by FPC was favorable to the contracting parties, essentially disclaiming jurisdiction over the Alaska production facilities, transportation, and terminal facilities used by Northwest Natural in Oregon.[2] In its staff review[3] of the decision, accompanied by briefs from several intervenors, the FPC overturned the majority of this decision. While they approved the project, the conditional terms of the approval were unacceptable to

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[2] U.S. Federal Power Commission, Initial Decision Upon Jurisdictional Issues (Phase I), Docket Nos. CI74-537, CI74-538, Jan. 15, 1975.

[3] U.S. Federal Power Commission, Opinon and Order Affirming in Part and Reversing in Part the Initial Decision Resolving Phase I (opinion No. 735), Docket Nos. CI74-537, CI74-538, June 23, 1975.

Phillips and Marathon, who subsequently withdrew from the original contract. The net result of this newly-claimed jurisdiction was too costly in terms of time, new certification requirements and regulation. For example, Northwest Natural has a "Hinshaw exemption" to the Natural Gas Act, which exempts the company from being classified as a natural gas company under FPC jurisdiction. To retain this status, Northwest Natural would now have had to form a subsidiary company (which would be under FPC jurisdiction) to import, store and revaporize the Alaskan LNG. Northwest Natural was willing to do this, but similar requirements were deemed untenable by Phillips and Marathon.

THE NATURE OF LNG

General Characteristics

LNG is a colorless, clear liquid which consists mainly of methane (CH_4), the simplest hydrocarbon. LNG also may contain varying small quantities of ethane, propane, nitrogen and other components normally found in natural gas. The LNG produced in Kenai, Alaska for which Northwest Natural originally contracted is unusually pure in methane, 99.6%, with the only measurable impurity being 0.4% of nitrogen.

Table 1 summarizes some physical characteristics of the main component of LNG, namely liquid methane. The most significant and apparent characteristic of LNG is its coldness. Because natural gas has a very low critical temperature, natural gas can not be liquified by pressure alone at ambient temperatures as is the case with propane, butane and other gases. It has therefore been necessary to develop systems which permit the transport and storage of natural gas at minus 260°F, just below the boiling point of the liquid. This is considered an ultra-low temperature requiring special precautions in handling and

TABLE 1

SELECTED PROPERTIES OF LIQUIFIED METHANE

Property	Value
Molecular weight	16.04
Atmospheric Boiling Point	-258.7°F -161.5°C
Liquid Density (at B.P.)	3.53 lb/gal 0.415 gm/cc
Gas Density	0.11 lb/cu. ft. 0.0018 gm/cc
Temperature at which Density of Methane Vapor = Density of Air	-155°F -104°C
Standard Cu. Ft. (SCF) of gas per Cu. Ft. of liquid (at B.P.)	630 SCF
Heat of Vaporization	220-240 Btu/lb 122-138 Gal/gm
Spontaneous Ignition	999°F 537°C
Laminar Burning Velocity	1.28 ft/sec 39.01 cm/sec
Flammable Range w/air,	5-14%

Source: Safety and Reliability of LNG Facilities. AMSE Report 72-Pet-53. September, 1972.

storage. Direct contact for short duration can cause severe tissue damage. Containers to hold LNG must be well insulated and carefully constructed with approved materials, such as the 9% nickel-steel alloy to be used for the Newport LNG tank.

Toxicity

While liquid methane is not toxic as such, its vapor may contribute to local anoxic conditions which may cause asphixiation if the oxygen level is sufficiently decreased. Natural gas of typical pipeline or LNG-plant quality, however, is more likely to cause some irreversible but non-fatal systemic changes upon low-level inhalation, due largely to impurities.[4]

Vaporization and Dispersion

LNG, exposed to a relative heat source such as water, soil or air, will boil and vaporize rapidly. Spills on water vaporize at a time-independent rate of 0.037 lbs per second per square foot of surface area.[5] Table 2 lists calculated vaporization rates on water. The rate of vaporization on soil depends on the soil type, degree of porosity, moisture content and artificial insulators used.[6] Initial rates are high, but evaporation tends to decrease to a constant rate several times lower than that on water.

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[4] Oceanographic Institute of Washington, Offshore Petroleum Transfer Systems for Washington State: A Feasibility Study, December, 1974, p. IV-158 to IV-166.

[5] U.S. Bureau of Mines, Hazards of LNG Spillage in Marine Transportation, Final Report to U.S. Coast Guard, February, 1970, p. 21.

[6] E.M. Drake and R.C. Reid, "How LNG Boils on Soil," Hydrocarbon Processing, May, 1975, V. 54.

TABLE 2

CALCULATED VAPORIZATION RATES OF LNG SPILLS ON WATER

Volume (gal.)	Duration (Min.)
100	0.3
1,000	0.65
10,000	1.4
100,000	3.0
1,000,000	6.5

Source: Hazards of LNG in Marine Transportation.
Bureau of Mines. February, 1970.

LNG is less than half as dense as water, and will spread out on the surface when spilled. The edge of a spill moves outward at a constant rate of 2.5 feet per second, regardless of spill size, attaining a maximum diameter according to the equation

$$d_{max} = 6.3\ W^{1/3}\ \text{Ft.}$$

where W is weight of LNG in pounds.[7] This equates to a pool diameter of about 960 feet for a million gallon spill on water. Vaporization of such an instantaneous spill would occur in about 6.5 minutes according to Table 2. This is about one half the volume which would be contained in each of the four spherical containers located on the proposed tanker for the Alaska-Newport route.

[7] U.S. Bureau of Mines, p. 21.

The fog-like cloud formed by evaporating LNG is initially heavier than air, accumulating in low places. When warmed above minus 160°F, it will become lighter than air, and disperse into the atmosphere. Dispersion is not uniform with peak concentrations in the vapor trail as much as 20 times larger than the time averaged concentrations predicted.[8] Inhibiting dispersion of the cold gas cloud is a layering effect, acting much like a strong temperature inversion does with air pollution.

Distances which flammable mixtures will travel downwind vary as a function of wind speed and variability, spill location, amount and duration. Calculations show that with a constant 5 mph wind, a spill on land contained in a 400 foot diameter pool (about the size of the Newport LNG tank dike) would result in flammable concentrations between 1000 and 4300 feet downwind after ten minutes. After 20 minutes the flammable envelope would be reduced to 700-2000 feet.[9] Downwind distances traveled on water are even greater, as shown by Bureau of Mines research.[10] The cloud disperses poorly due to layering and can remain flammable for long distances downwind. Calculations which were based on experimental testing showed that under gusty 16 mph wind conditions, a large near-instantaneous LNG spill of 6.6 million gallons (or about 85% the volume of the originally proposed LNG ship) would create a far-reaching downwind plume. The distance calculated for the 5% average gas concentration (the lower limit of flammability) was 1.7-2.9 miles, as shown in Table 3. LNG spills with steady rates of release also show substantial downwind hazard zones, as shown in Table 4. These latter values hold more significance than those in Table 3, because the most likely spills are the steady release rate variety.

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[8] Ibid., p. 34.

[9] W.W. Crouch and J.C. Hillyer, "What Happens When LNG Spills?" Chemical Technology, April, 1972, V, p. 213.

[10] U.S. Bureau of Mines, Hazards of Spillage of LNG into Water, Final Report to U.S. Coast Guard, September, 1972.

Table 3

Calculated Distances to End of Flammable Zone
(following release of 6.6 million gallons of LNG on water)

Gustiness Category	Average Wind Speed, mph	Distance (miles) to 5% Average	5% Peak	0.25% Average
B_2 (unstable)	8	1.3 - 2.3	4.7-	6.7-
B_1 (unstable)	16	1.7 - 2.9	6.3-	9.5-
C (neutral)	24	3.1 - 6.0	13.7-	21.2-
D (stable)	7*	18.5 - 37.9	-----	-----

* Assumed for sake of calculation; we have no information as to a representative wind speed under inversion conditions.

SOURCE: Hazards of LNG Spillage Into Water. Bureau of Mines. September, 1972.

Table 4

Calculated Distances to End of Flammable Zone with Steady Release Rate of LNG

(Gusty with 16mph average wind)

Leak Rate gal/sec	Evaporation Rate ft^3/sec	Distances (feet) to 5% average	5% peak	0.25% average
20	1,570	240	900	1,400
200	15,700	900	3,300	4,900
2,000	157,000	3,300	13,000	18,000

SOURCE: Hazards of LNG Spillage Into Water. Bureau of Mines. September, 1972.

When the LNG spilled is contained within barriers, it is possible to control vaporization somewhat. The application of high expansion foam has been shown to effectively reduce the vaporization rate, thus limiting the extent of flammable gas-air mixtures.[11] Water spray can be effective in keeping the vapor cloud contained in an area by creating a physical barrier. Both methods could be used to reduce the possibility of ignition should a confined spill occur.

Flammability and Related Hazards

Natural gas-air mixtures of 5-14% are flammable. However, due to layering and poor dispersion of the cold vapor over water, and to the existence of peak concentrations in the vapor trail, gas-air mixtures with time-averaged concentrations of only 0.25% natural gas have been shown to be flammable (Peak concentrations were over 5%).[12] This significantly extends the downwind hazard area.

Sources of energy which must be considered as potential ignition sources include open flames, naked lights, lighted cigarettes, electrical sparks, sparks or heat from impact of materials, static electricity, hot surfaces, motors, engines and turbines. Of the common hydrocarbon fuels, however, LNG has the lowest probability of vapor ignition, as well as a low flame velocity, indicating that neither a sudden flash or detonation will occur upon ignition.[13] Once the gas-air mixture is ignited, however, the flame will propagate back to the source, if gas concentrations are sufficient along the entire path. Isolated pockets might burn out.

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[11] J.R. Welker, H.R. Wesson and L.E. Brown, "Use Foam to Disperse LNG Vapors?" Hydrocarbon Processing, V. 53, p. 119.

[12] U.S. Bureau of Mines, "Hazards of Spillage of LNG into Water," p. 44.

[13] Ibid., p. 8.

Ignited LNG vapor would pose a continuous radiant heat problem. With a confined spill on land (e.g. in a diked area around an LNG tank), personnel within 900 feet, if unprotected, would suffer blistering in 30 seconds and combustible materials, such as wood, paper, grass, rubber and plastics would ignite as far away as 500 feet.[14] Wind would increase these distances in the downwind area, due to the bending of the flame and heat transport. On water, the radiant heat problem of an LNG fire is more severe.[15] This is due to the spreading pool and an accelerated vaporization rate. Figure 3 shows various radiant heat distances and effects as a function of LNG pool radius.

Control of LNG fires has been the subject of much study. Extinguishing agents which can put out LNG fires include dry chemical, carbon dioxide and halogenated hydrocarbons. Foam and water will not extinguish LNG fires. Whatever method used, the agent must work quickly and completely, or the residual high temperatures or remaining pocket of flame will quickly cause reflashing of the fire back to original proportions. A secondary means of control involves absorbing some of the heat generated by a pooled LNG fire using water as the control agent. Water can be applied using either a fixed or portable system, thus lending flexibility in reducing the radiant heat problem.

Flameless explosions termed vapor explosions have occurred during experimental spills of LNG on water.[16] While infrequent, they were quite violent and could not be explained. Further work by the Bureau of Mines[17] showed that the explosion hazard is relatively insignificant compared to the primary hazard of large flammable gas cloud formation discussed

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[14] A.E. Uhl et. al., Safety and Reliability of LNG Facilities (American Society of Mechanical Engineers), Report 72-Pet-53, July 1, 1973, p. 4.

[15] American Gas Association, LNG Spills: To Burn or Not to Burn (Operating Section, Distribution Conference, Philadelphia, PA.), 1969.

[16] U.S. Bureau of Mines, "Hazards of LNG Spillage in Marine . . ."

[17] U.S. Bureau of Mines, "Hazards of Spillage of LNG into Water."

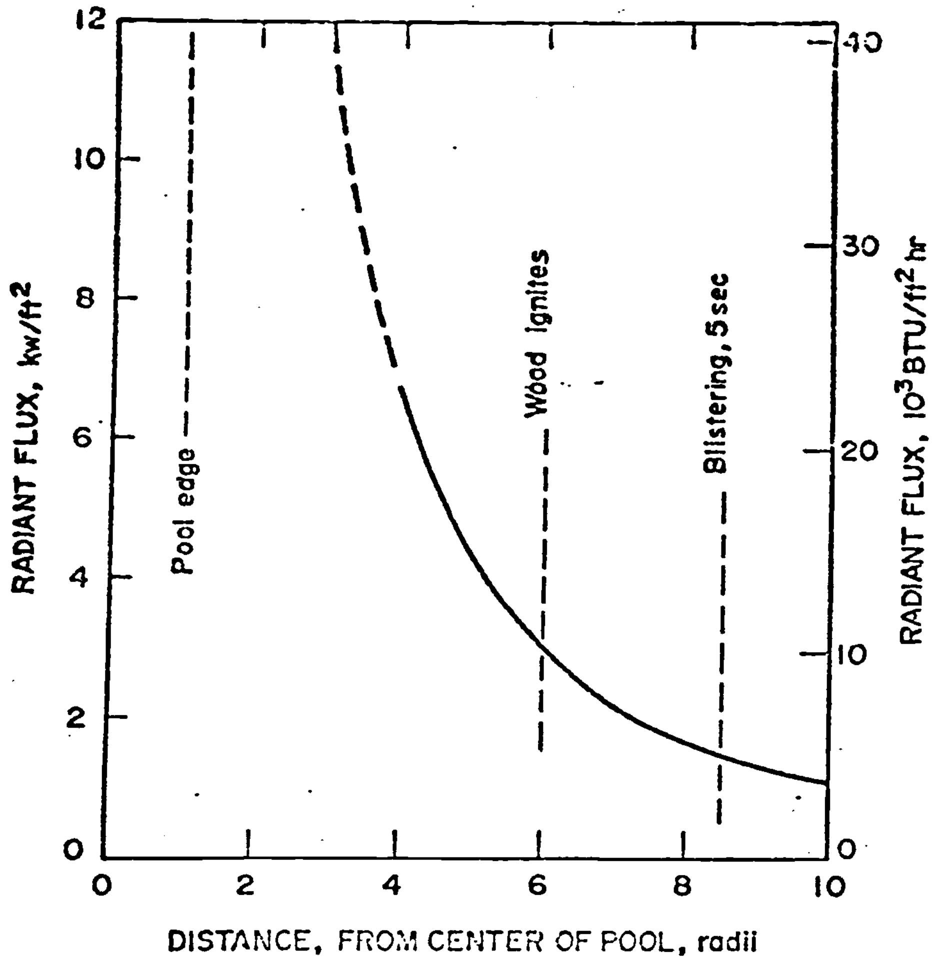

Figure 3. Radiant Heat Flux Near a Burning Pool of LNG on Water.
Assumed vaporization rate=0.047 lbs/ft^2 sec
Windless Condition With Radiant Power = 0.4 Total Thermal Power

Source: Bureau of Mines, Hazards of LNG Spillage onto Water, September, 1972.

above. It was shown in this and other work that the incidence of vapor exposions is markedly reduced, if not completely eliminated, by preventing a build-up in the concentrations of the heavier hydrocarbons in LNG. Alaskan LNG (99.6% methane) never exibited the vapor explosion phenomena. While the possibility of structural damage resulting from a vapor explosion exists, it was insignificant when compared to other hazards. Ignition was never observed in these or other tests conducted. The mechanism of vapor explosion is still not known, but there have been numerous theories advanced on the subject.

NOTE:

The following two sub-sections of Section I are background information on Yaquina Bay and are not directly related to the evaluation of the LNG project. The reader may wish to skim this material and refer back to it later as the need arises.

YAQUINA BAY ESTUARY

In contrast to the relatively static physical environment of the surrounding uplands, the bay-river system and adjacent wetlands are part of an extremely dynamic system which is undergoing constant temporal and spatial changes. The driving forces of this system are principally the tides and streamflow variations, which result in turbulent mixing, transport of organic and inorganic materials, temperature and chemical gradient variability, and various biological and geochemical processes. These and other factors contribute to the daily, monthly and seasonal rhythms which make the estuarine ecosystem so unique.

Geography

Yaquina Bay forms the submerged river valley portion of the Yaquina River drainage basin (Figure 4). The river drains 253 square miles and has a relatively short 58.8 mile length, with only one major tributary, Elk Creek. Almost 90% of the drainage basin is forest land (much of it managed for timber harvest), with the rest divided among crop, pasture, urban and other uses.

Yaquina Bay and River to mile 26 form an estuary,[18] with a permanent salinity gradient from head to mouth. The estuary covers 3910 acres at mean high tide (MHT) of which 1353 are wetlands at mean low tide (MLT). The wetlands in turn consist of 534 acres of mud and sand flats and 819 acres of tidal marsh. Major tideflat areas include Sally's Bend and Southbeach Mudflat. The major marsh areas are within McCaffery and Poole's Sloughs and along the riverbanks from Oneatta Point to Toledo.

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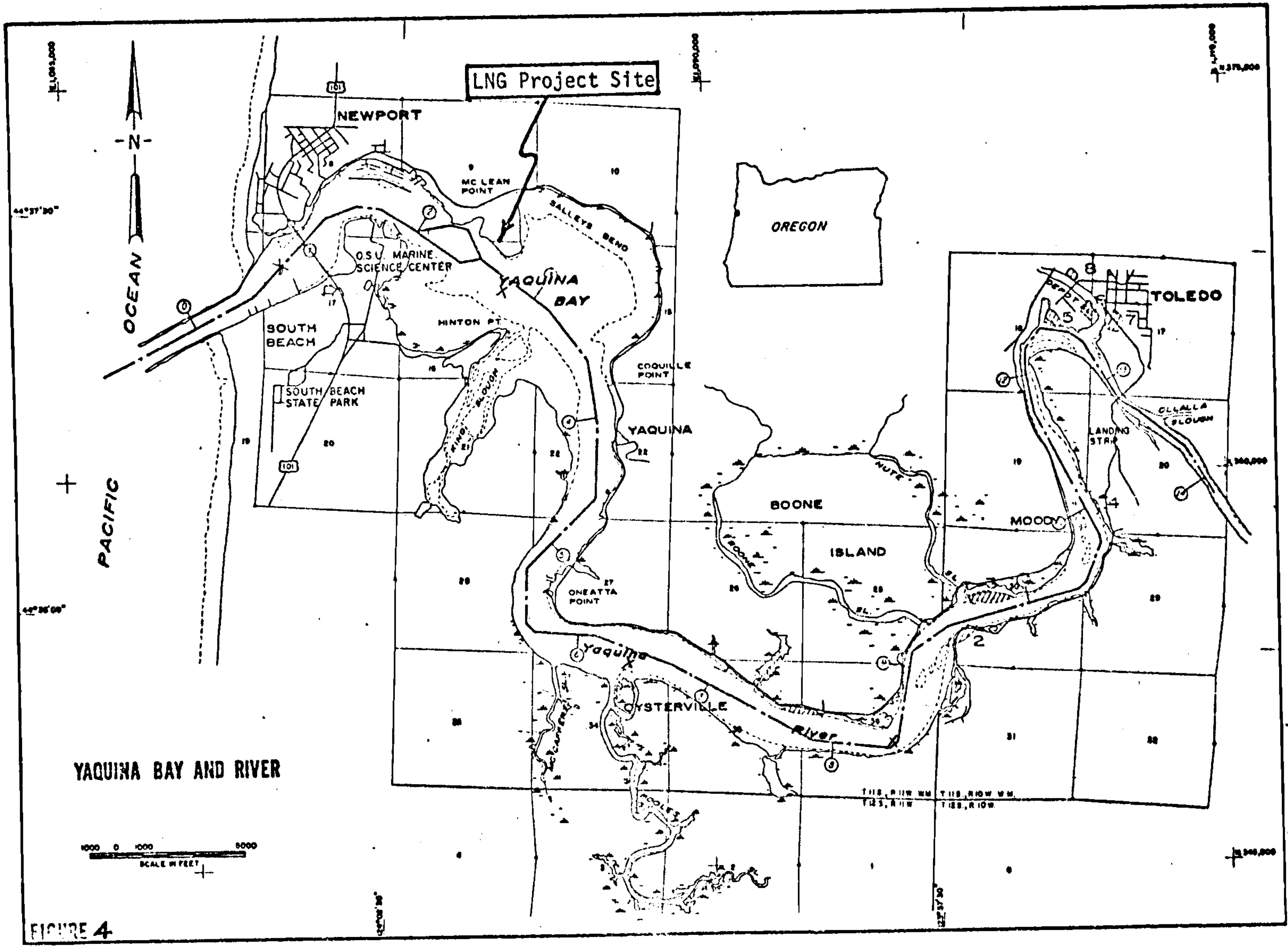
[18] Estuary is defined as a semi-enclosed body of water which has a free connection to the sea and within which sea water is measurably diluted with fresh water from land drainage. (after D.W. Pritchard, "What is an Estuary: Physical Viewpoint", in Estuaries, ed. Lauff, AAAS, 1967.)


LNG Project Site
N
NEWPORT
101
MC LEAN POINT
SALLEYS BEND
O.S.U. MARINE SCIENCE CENTER
YAQUINA BAY
OCEAN
PACIFIC
SOUTH BEACH
HINTON PT
KING SLOUGH
SOUTH BEACH STATE PARK
COQUILLE POINT
YAQUINA
OREGON
TOLEDO
DEPOT SL
OLALLA SLOUGH
LANDING STRIP
BOONE
ISLAND
NUTE SL
BOONE SL
MOODY
ONEATTA POINT
Yaquina River
OYSTERVILLE
MCCAFFERY SL
POOLE SL
YAQUINA BAY AND RIVER
SCALE IN FEET
FIGURE 4

Yaquina River streamflows are fairly low compared to the adjacent Siletz and Alsea (Figure 5). The average annual yield of 780,000 acre feet is unevenly distributed over the year as the result of differences in precipitations (Figure 6). Average stream flows vary from about 1650 cu. ft. per second (cfs) in February to lows of less than 100 cfs in August, September and October.

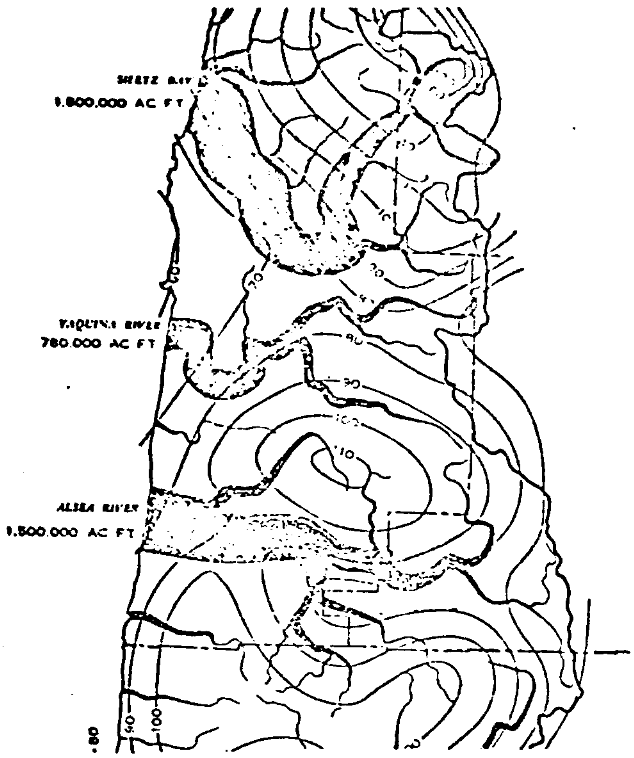
Climate

The climate of the Yaquina Bay area is characterized by marked wet and dry seasons, mild and rather uniform air temperatures, seasonal wind fluctuations and lower than normal solar radiation for the latitude (44° 38'N). Average precipitation at Newport is 68 inches with about 70% occurring in November through March. Precipitation within the drainage basin ranges up to 100 inches per year. Average temperature at Newport is 51°F, with monthly averages of 43.5°F in January and 58°F in August. Winds exibit a seasonal pattern of variation, with north and northwest winds predominating in summer months and south to southeast winds most common in winter. This seasonal cycle is primarily the result of circulation about the North Pacific high pressure area in summer, and the Aleutian low pressure area in winter. The summer north winds are responsible for the periodic upwelling of cold nutrient-laden bottom waters which substantially contribute to the high biological productivity of Pacific Northwest Coastal waters.

Tides, Currents and Salinity

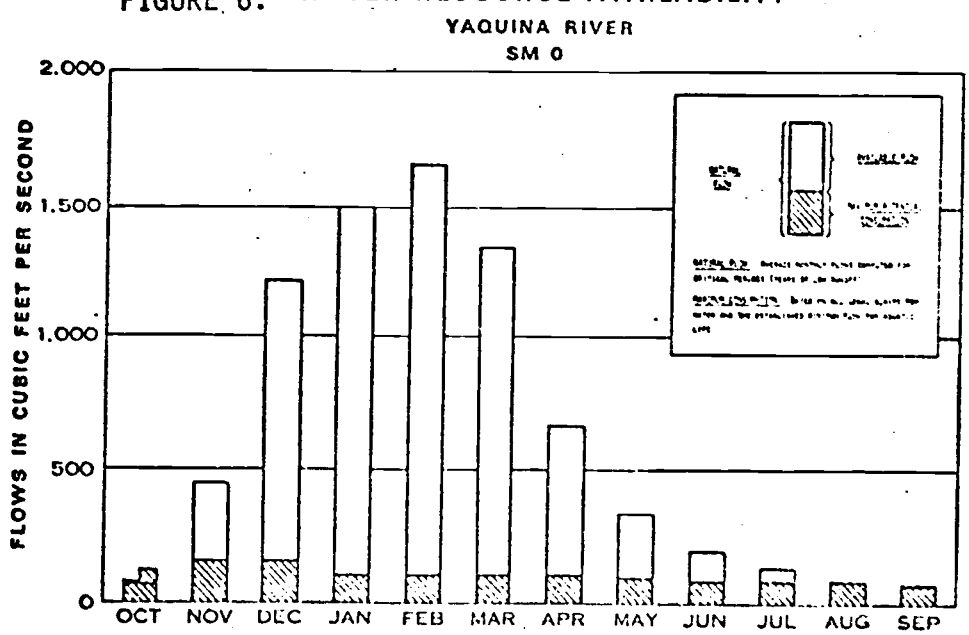
Circulation within the Yaquina estuary is controlled primarily by tidal forces, variations in bottom geometry and cross-sectional area and by fluctuations in freshwater runoff entering the estuary. Winds and periodic upwelling of offshore waters may also influence circulation

FIGURE 5. Precipitation and Yield (Siletz, Yaquina & Alsea River Basins)



Source: State Water Resources Board, Mid-Coast Basin, May,1965.

FIGURE 6. WATER RESOURCE AVAILABILITY



Source: OCC&DC, Freshwater Resources of the Oregon Coastal Zone, December, 1974.

over the short-term. Contrary to one report,[19] coriolis force[20] probably has minimal effect on Yaquina estuary circulation patterns.

The tides in Yaquina Bay are mixed semidiurnal tides, with paired highs and lows of unequal duration and amplitude. The mean tidal range at OSU Maine Science Center is 6.0 feet, while the diurnal tidal range (the range between the highest and lowest tides occurring during one tidal day) is 8.0 feet. As shown by Neal,[21] tidal conditions nearly satisfy all the requirements for a standing tidal wave. Specifically, the range of tide increases as you proceed upstream, with high tides and low tides occurring nearly at the same time (within 30 minutes) at all sites studied. For example, the high tide at U.S. 101 Bridge of +6.0 feet will occur about the same time as the +6.8 foot tide at Toledo. In addition, maximum tidal currents were associated with mid-tide levels, though lagging by as much as 60 minutes. This also fits standing wave-requirements. The volume, or wedge of water that moves in and out of Yaquina estuary is defined as the tidal prism. The tidal prism based on a mean tidal range of 6.0 feet is about 940 million cubic feet and the diurnal tidal prism is about 1250 million cubic feet, according to Corps of Engineers estimates.

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[19] Bureau of Governmental Research and Service, Preliminary Land Use Plan for the Yaquina Bay Area (University of Oregon, September, 1969). (P. 17 states that ". . . the direction of water circulation is controlled by coriolis acceleration . . . a counter-clock-wise circulation pattern develops." Actually, this is only one factor in estuarine circulation and may often be negated or reversed by other factors, particularly bottom geometry and basin shape).

[20] Coriolis force is an apparent force acting on a body in motion (e.g., a parcel of water) due to the rotation of the earth and causes a body to be deflected to the right in the northern hemisphere and to the left in the southern hemisphere.

[21] V.T. Neal, "Tidal Currents in Yaquina Bay," Northwest Science, 1966, V. 40, p. 68-74.

The cross-sectional area of Yaquina estuary is illustrated in Figure 7. Much of the increase from the mouth to McLean Point is due primarily to the dredging of the channel and the 1200 foot wide turning basin opposite McLean Point. The author's estimate of what the cross-sectional area may have looked like prior to alteration of the estuary is shown by the dotted line; this is typical for a drowned river valley estuary with a constricted mouth. Based on Figure 7 an estimate of estuary volume is about 1600 million cu. ft.

The seasonal freshwater flow is greatest during winter and spring months and lowest during summer (Figures 5, 6). If tidal and basin characteristics are viewed as constant, river discharge is the principle factor which effects the type of estuarine system present at any one time during the year. River discharge is a function of precipitation rates, so circulation patterns are indirectly controlled by precipitation.

Under low-flow summer conditions sea water penetrates far upriver and Yaquina estuary is classified as "well-mixed," based on minimal variations in top to bottom salinity measurements. Circulation in the estuary at this time, according to theory, is characterized by a slow net nontidal flow toward the ocean at essentially all depths.

Under high flow conditions in winter, the estuary is classified as "partly-mixed," though particular areas may be well mixed (e.g. over tidal flats). The denser salt water tends to form a wedge under the outflowing fresh water. Top layers show large net flow toward the ocean while a net upstream flow is registered in bottom layers. On rare occasions, when extremely high streamflow is combined with weak tides, a

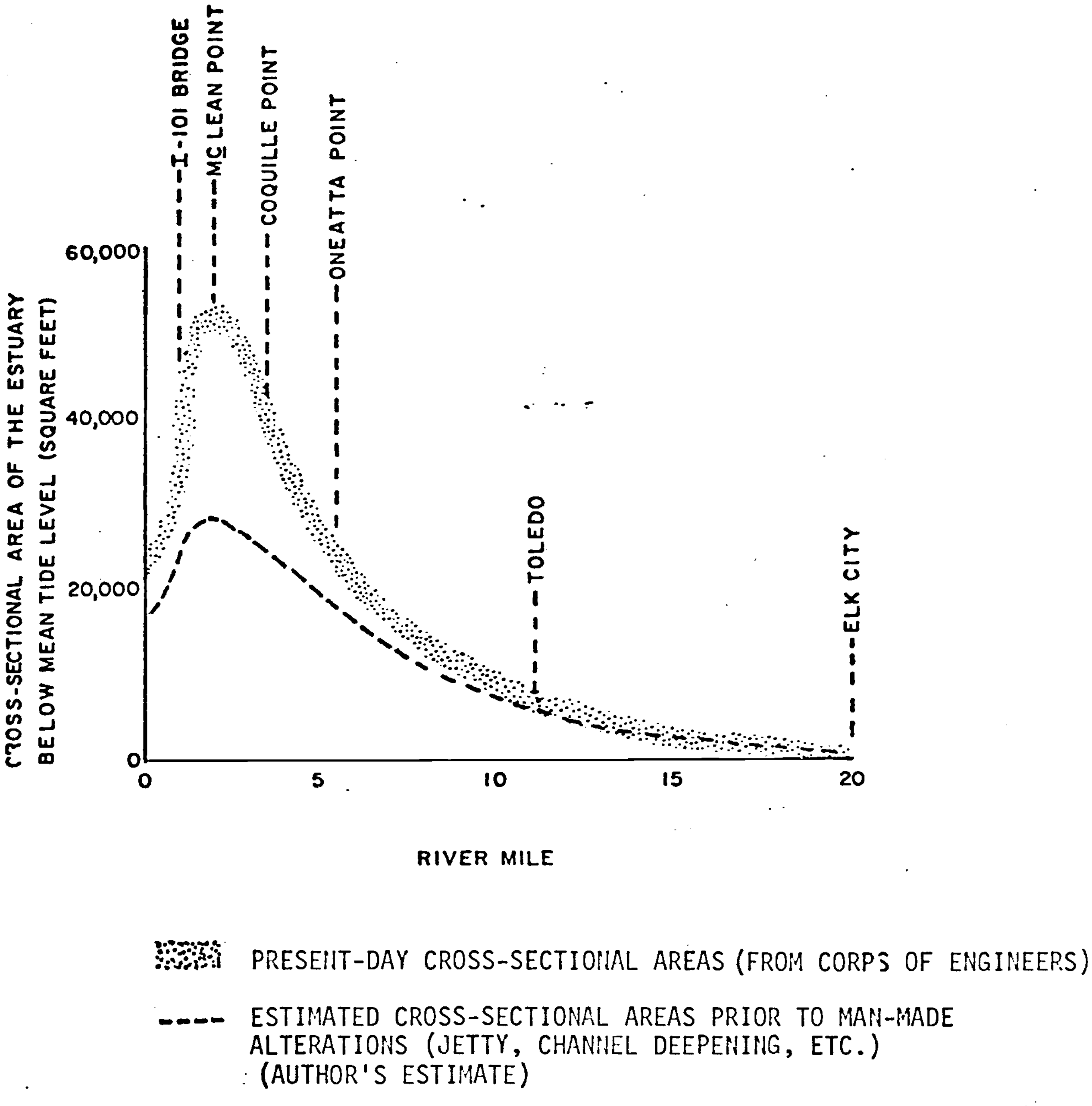

FIG. 7. CROSS - SECTIONAL AREAS OF THE YAQUINA ESTUARY

Source: U.S.Army Corps of Engineers, Draft Environmental Impact Statement, Yaquina Bay and River, March, 1975.

two-layered "stratified" system will develop, with surface fresh water extending nearly to the mouth.

Sediments

The Yaquina estuary is an aggrading system, which is to say that the rate of sediment deposition within the estuary exceeds the rate of natural removal, with the result being a gradual filling of the basin. Maximum deposition occurs in winter with little occurring during summer.

Both organic and inorganic sediments are deposited to the estuarine benthic system. Inorganics, including sands, silts and clays are introduced from the ocean, from upstream, and from local runoff. Organics originate from sources outside the estuary (such as wood particles) as well as from primary production of phytoplankton, algae and aquatic plants within the estuary.

Three realms of sediment deposition exist within the estuary.[22] Marine sediments dominate the bay up to Sally's Bend. A transition marine-fluvatile zone extends just beyond Oneatta Point (about six miles from the mouth), where marine-derived sands end. Upriver is the fluvatile zone, but during high streamflow periods, much fluvatile sediment is carried as suspended load and dumped in the Sally's Bend area. The Southbeach flat derives some of its marine sands from the unstable dunes to the west of it. The majority of marine sediments, however, move directly into the estuary through its mouth (Figure 8). These sands originate predominantly from beaches to the south and are transported via longshore drift, a phenomenon which is a result of impingement of

[22] L.D. Kulm and John V. Byrne, "Sediments of Yaquina Bay, Oregon," in Estuaries, ed. George H. Lauff (Washington, D.C.: American Association for the Advancement of Science, 1967), p. 226-238.

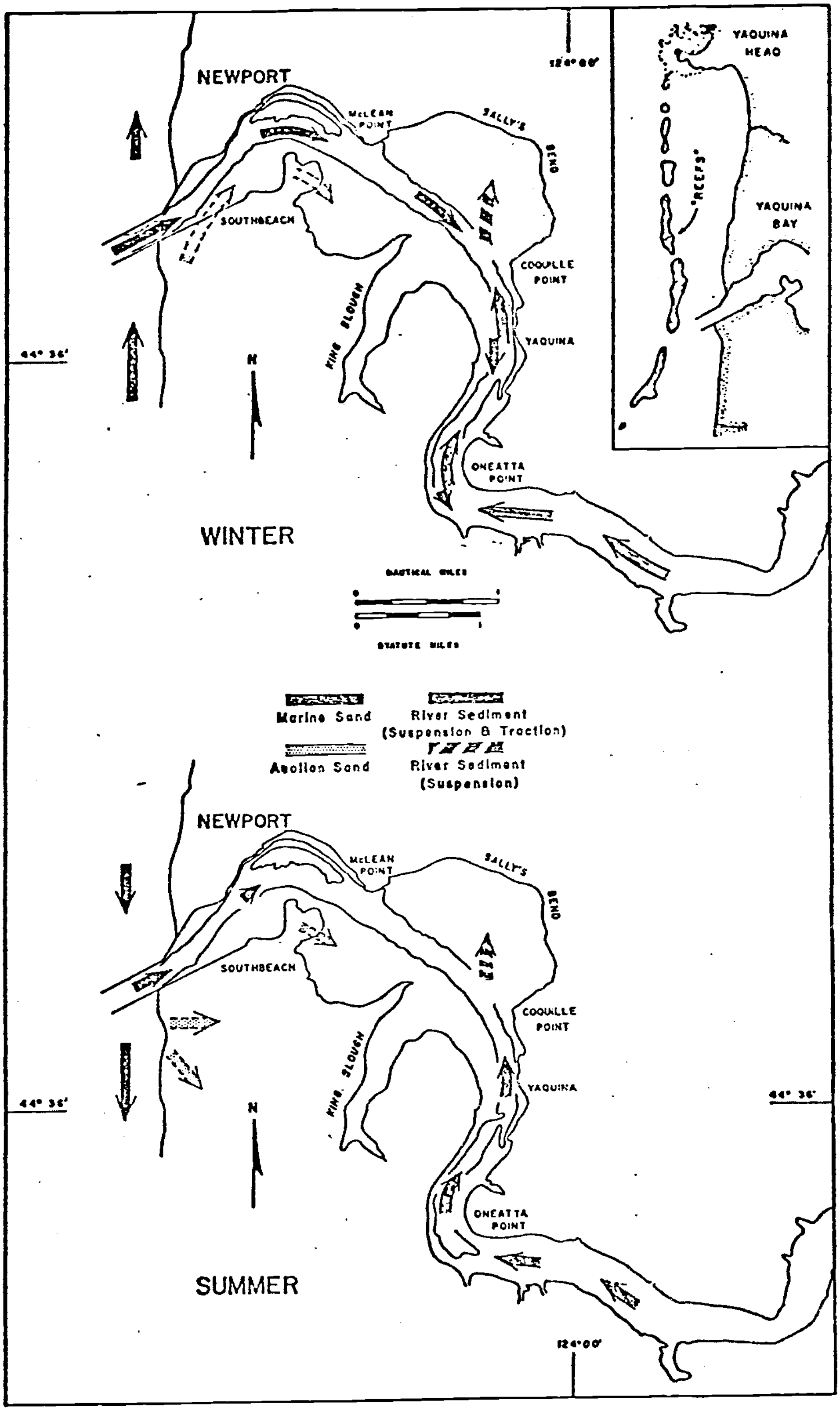

FIGURE 8. Inferred Seasonal Deposition Patterns in Yaquina Bay. The lengths of arrows indicate the relative magnitude of sediment deposition by the various processes.

Source: Kulm & Byrne, "Sediments of Yaquina Bay, Oregon," in <u>Estuaries</u>, ed. Lauff, 1967.

wave energy upon the shore at an oblique angle. The current along the shore set up by this movement carries suspended particles of sand great distances. Eventually, the sand ends up on distant beaches or is carried into estuaries by tidal flood currents.

No quantitative measurements of marine sediment transport have been made. However, some idea of the volume involved can be ascertained by Corps of Engineers dredging records. An annual average of 503,000 cubic yards of material are removed from the channel entrance and inner bay up to the town of Yaquina.[23] Most of this material is of marine origin.

Living Resources of Yaquina Estuary

The wide variety of habitats, the dynamic character of physical forces, sediment and chemical distribution, all combine to provide conditions for a high diversity of life in estuaries. To merely describe the different habitats and their various flora and fauna is too simplistic if the true nature of the estuarine environment is to be appreciated. For example, in his exhaustive study of the role of tidal flats in estuarine water quality,[24] Bella described five types of estuarine benthic systems (tideflats) as a function of their relative organic and inorganic sediment deposition rates. Through the effect on dissolved oxygen levels, free sulfide release and other parameters, the differential sedimentation rates were correlated with biological diversity and abundance. Many man-made disturbances have been shown to cause a decrease in both of

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[23] U.S. Army, Corps of Engineers, Draft Environmental Impact Statement: Operation and Maintenance of Channels and Breakwaters in Yaquina Bay and River, Oregon (Portland District, March, 1975), p. 1-4.

[24] David A. Bella, Tidal Flats in Estuarine Water Quality Analysis, A report prepared for Water Quality Office, U.S. Environmental Protection Agency (Department of Civil Engineering, Oregon State University, August, 1973), p. 59.

these characteristics, which is generally considered detrimental. Every estuarine habitat type has its own controlling factors which impact living resources in similar ways. Armed with this knowledge, be it factual or intuitive, it behooves man, whose coastal economy is often based on these living resources, to carefully consider the "disturbances" (commonly labeled improvements) he wishes to make to assure a net long-term benefit.

The Oregon Coastal Conservation and Development Commission (OCCDC)[25] classified the Yaquina Bay estuary into two management units as follows:

1. Yaquina Bay and River--high marine biological value and high terrestrial biological value with a moderate percentage of eelgrass (<10%) and tidelands (31-40%).

2. McCaffery and Pooles Sloughs--Moderate marine biological value and high terrestrial biological value with a high percentage of eelgrass (>10%) and high percentage of tidelands (>40%).

While the OCCDC estuarine inventory provided some general information for a statewide perspective of estuarine resources, it is of little value to local estuary managers other than as an introduction. Yaquina Bay, however, has the distinction of being perhaps the most studied of Oregon estuaries, due to its proximity to Oregon State University, and the location of the Marine Science Center on the bay. Some of the most comprehensive compilations of information, however, have been performed by government agencies.

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[25] Oregon Coastal Conservation and Development Commission, <u>Estuarine Resources of the Oregon Coast</u>, September, 1974, p. 135.

In 1968, the U.S. Bureau of Sports Fisheries and Wildlife prepared a report[26] on the fish and wildlife of Yaquina Bay in an ecological and biological context. This study was an important resource in the preparation of the Preliminary Land Use Plan for the Yaquina Bay Area and in subsequent publications by other agencies.

The Corps of Engineers in their draft EIS[27] produced for the Yaquina Bay and River dredging made a comprehensive compilation of information concerning living resources of the Bay area, covering fish, shellfish, waterfowl and terrestrial shoreland and upland species particularly well.

An excellent description of the various plant and animal benthic organisms and their importance to the estuarine environment was made by Bella in his study of tidal flats.[28] The great variation in size, from large invertebrates to microscopic animals, plants and bacteria living between the sediment particles was discussed. The ecological role of the various feeding mechanisms employed was also presented. A great diversity of organisms rework the sediments, remove turbidity from overlying waters, and break down organic matter to basic nutrients, providing an essential link in an efficient recycling system.

Numerous other studies on all aspects of Yaquina Bay's living resources are available at the OSU Marine Science Center. A comprehensive study of Yaquina estuary should include a review of these sources of information.

A series of living resource maps from several sources are reproduced as Figures 9A-9E.

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[26] U.S. Department of Interior, Fish and Wildlife Service, Fish and Wildlife of Yaquina Bay (Portland, 1968).

[27] Corps of Engineers, p. 2-11 to 2-31.

[28] Bella, p. 20.

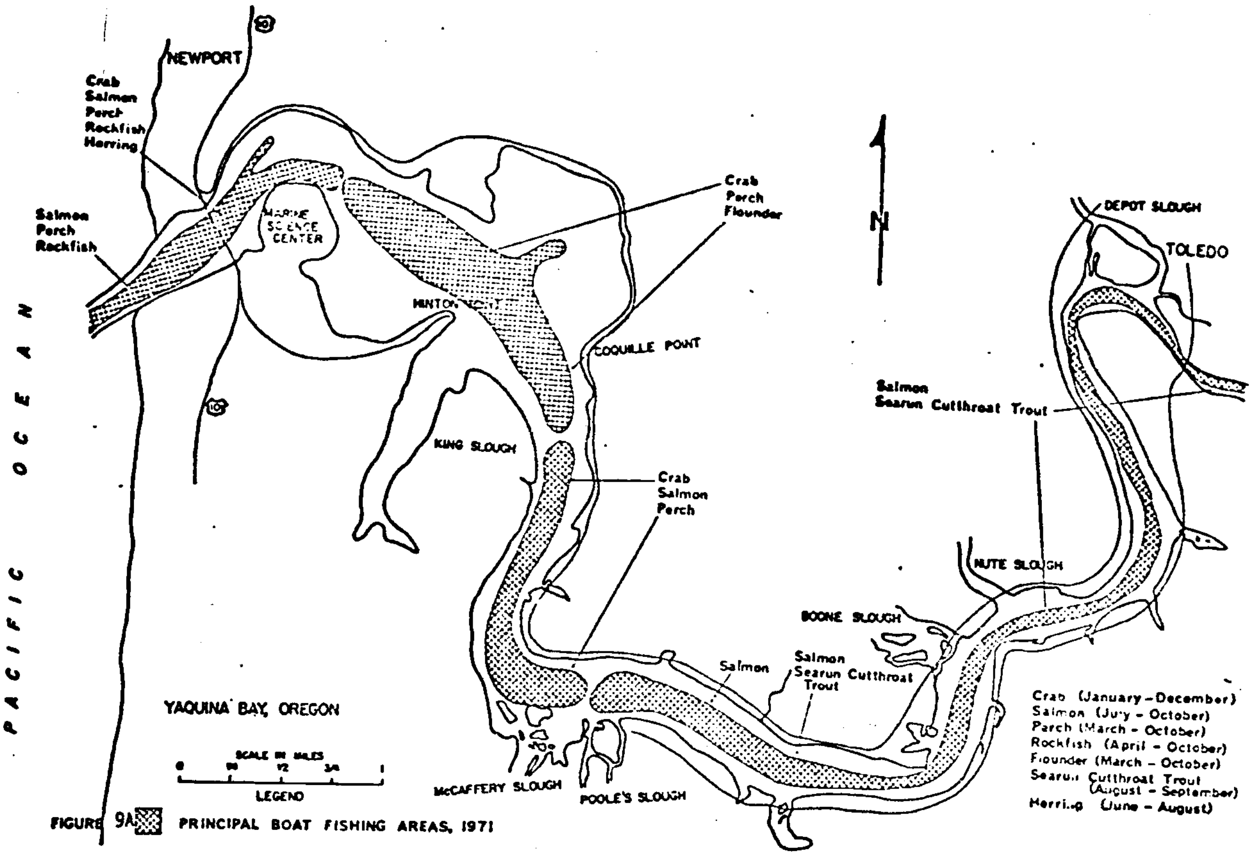


FIGURE 9A PRINCIPAL BOAT FISHING AREAS, 1971

Source: Fish Commission of Oregon, Yaquina Bay Estuary, A Study in Resource Use, February, 1974
(also for 9B through 9E)

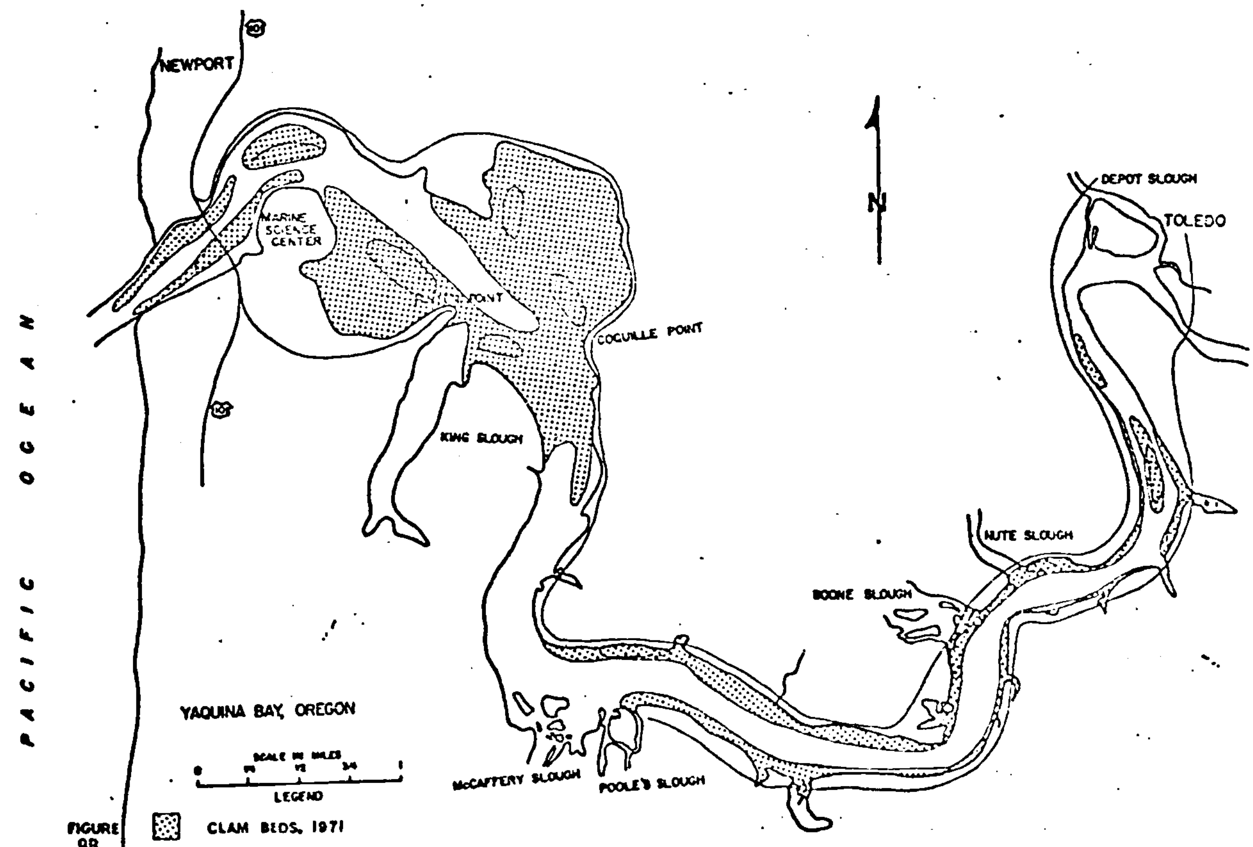


FIGURE 9B CLAM BEDS, 1971
PRINCIPAL DIGGING AREAS

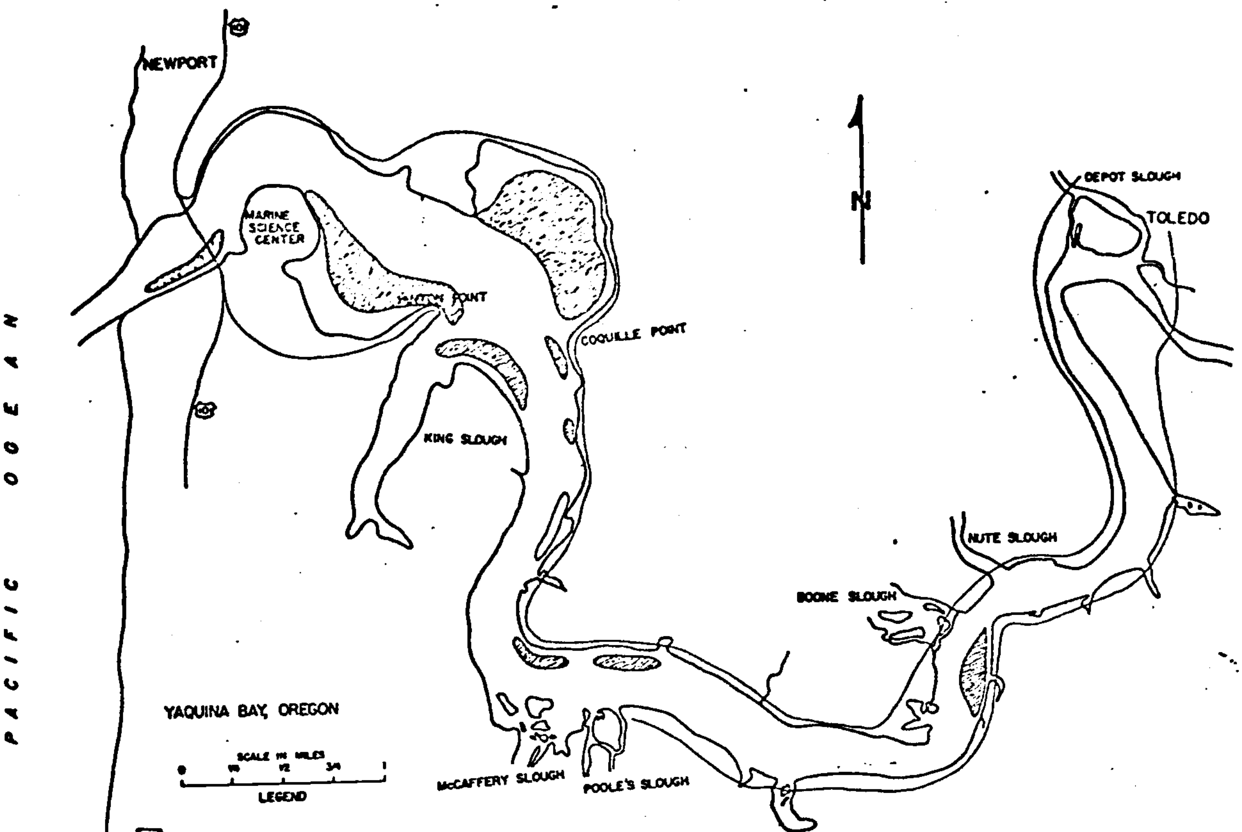


FIGURE 9C — EEL GRASS BEDS, 1971

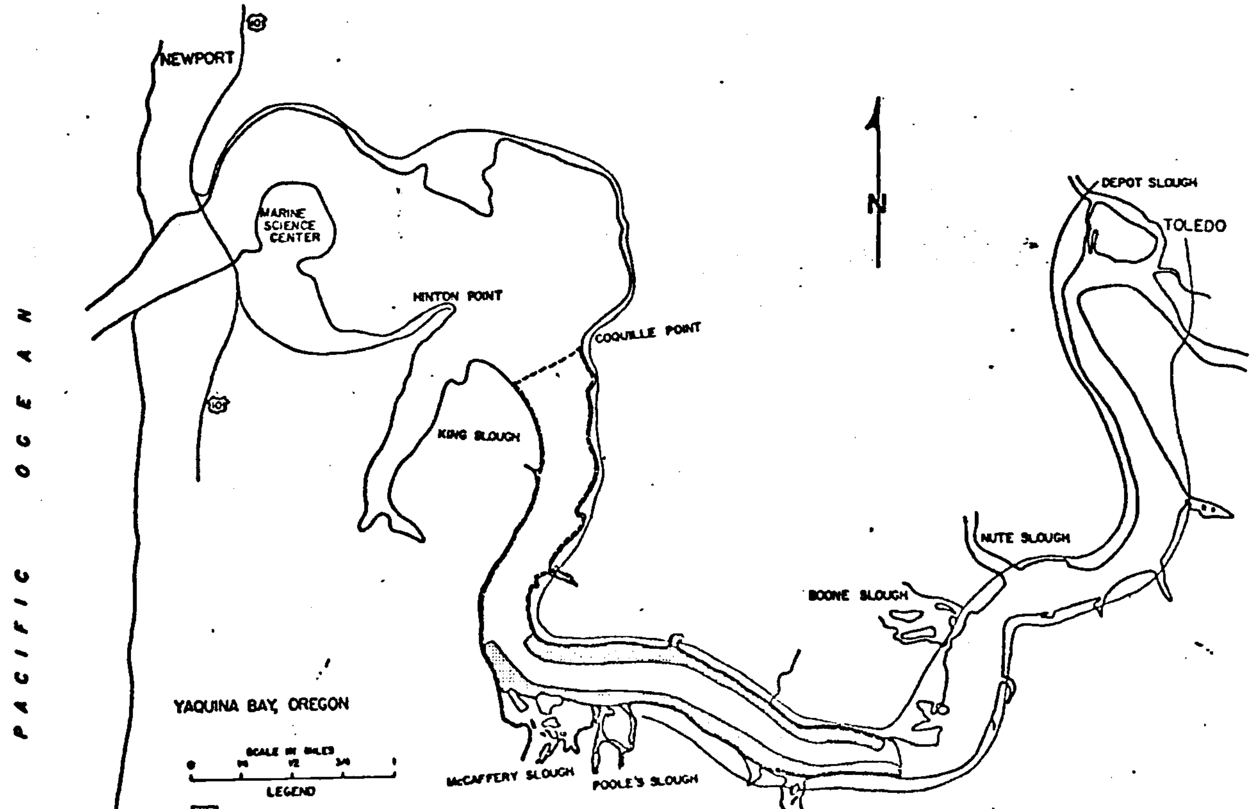
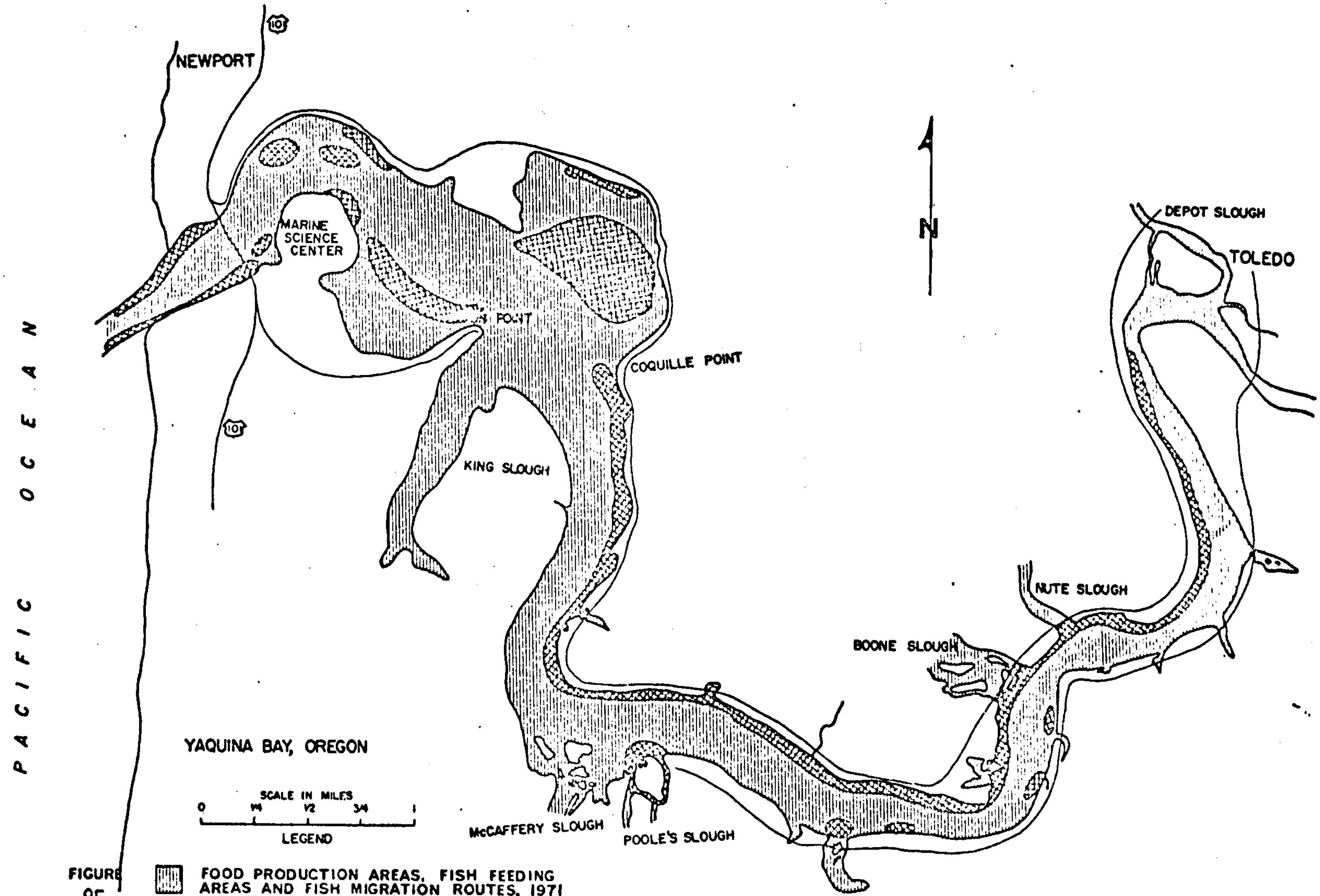


FIGURE 9D — COMMERCIAL OYSTER LEASES, 1971
POTENTIAL OYSTER GROWING AREA



LEGEND

FIGURE 9E

FOOD PRODUCTION AREAS, FISH FEEDING AREAS AND FISH MIGRATION ROUTES, 1971

KNOWN HERRING SPAWNING AREAS

Physical Alterations[29]

Yaquina Bay was one of the first harbors on the Oregon coast to have navigational improvements with the original north and south jetties completed in 1896. Extensions and repairs have been made periodically; the north jetty was extended to its present length in 1966 and the south jetty completed in 1971. An 800 foot spur jetty and five groins have been constructed along the channel side of the south jetty.

A 400 foot wide entrance channel is dredged annually to 40 feet, while a 300 foot wide channel to Newport harbor and 1200 foot wide turning basin opposite McLean Point is maintained at 30 feet. Northwest Natural Gas recently (May 1974) had a 300 x 1750 foot ship berth dredged to 30 feet opposite their property, extending from the existing turning basin. A turning basin and small boat basin are also located within Yaquina harbor, protected by a 2650 foot-long bulkhead-type breakwater.

A 200 foot wide, 18 foot-deep channel extends from Newport to the town of Yaquina, where it lessens to a 150 foot wide, 10 feet deep channel to Toledo.

In addition to the above alterations two levees with tide-gates and bulkheads were constructed along the north bank of the Yaquina River in 1948 at Boones and Nutes Sloughs. Most of the Newport waterfront is bulkheaded or riprapped, with numerous small boat and commercial docks. Commercial wharves are located at Sunset Terminals area; docks and a small breakwater are located on the south side of the bay which belong to the Marine Science Center. Numerous small boat moorages occur along

[29] Corps of Engineers, (Most information concerning physical alterations is derived from the draft environmental impact statement).

the river's navigable length and a major boat basin project (700 moorages) has been funded and is being undertaken by the Port of Newport to the west of the Marine Science Center. A hotel-convention center (Nendel's) is to be constructed on the waterfront adjacent to the boat basin. The entire complex will be about a $10 million investment and is due for completion by Summer, 1977.

The State of Oregon filled lands inventory[30] reports that 253 acres of landfill exist within Yaquina estuary. Approximately 55 acres were on submerged lands with the remaining 198 acres on tidelands. Yaquina Bay thus has 14.6% of its tidelands filled, as compared to 3.5% for all of Oregon. Major uses of landfill areas include the soon-to-be constructed LNG import terminal and marina-hotel-convention center, log storage, OSU Marine Science Center, moorages, docks and roadbeds along the estuary perimeter. Waterfront roadways are often rip-rapped to limit erosion.

Existing Water Quality

The Oregon State Department of Environmental Quality (DEQ) periodically monitors water quality in the Yaquina Bay and River. Figure 10 summarizes some data collected by DEQ from 1960-73 on dissolved oxygen and coliforms. More complete data is available the STORET Data Retrieval[31] System. Water quality parameters monitored include temperature, turbidity, color, conductivity, dissolved oxygen (DO), biochemical oxygen demand (BOD), pH, salinity, total and fecal coliforms, total alkalinity, residue, nitrogen (both ammonia and nitrate), orthophosphate, total hardness, sulfate and chloride. Not all parameters are monitored at each site,

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[30] Oregon State Land Board (Advisory Committee), Inventory of Filled Lands: Yaquina Bay, . . . Alsea River, 1972.

[31] U.S. Environmental Protection Agency, STORET Data Retrieval System (Seattle, Washington).

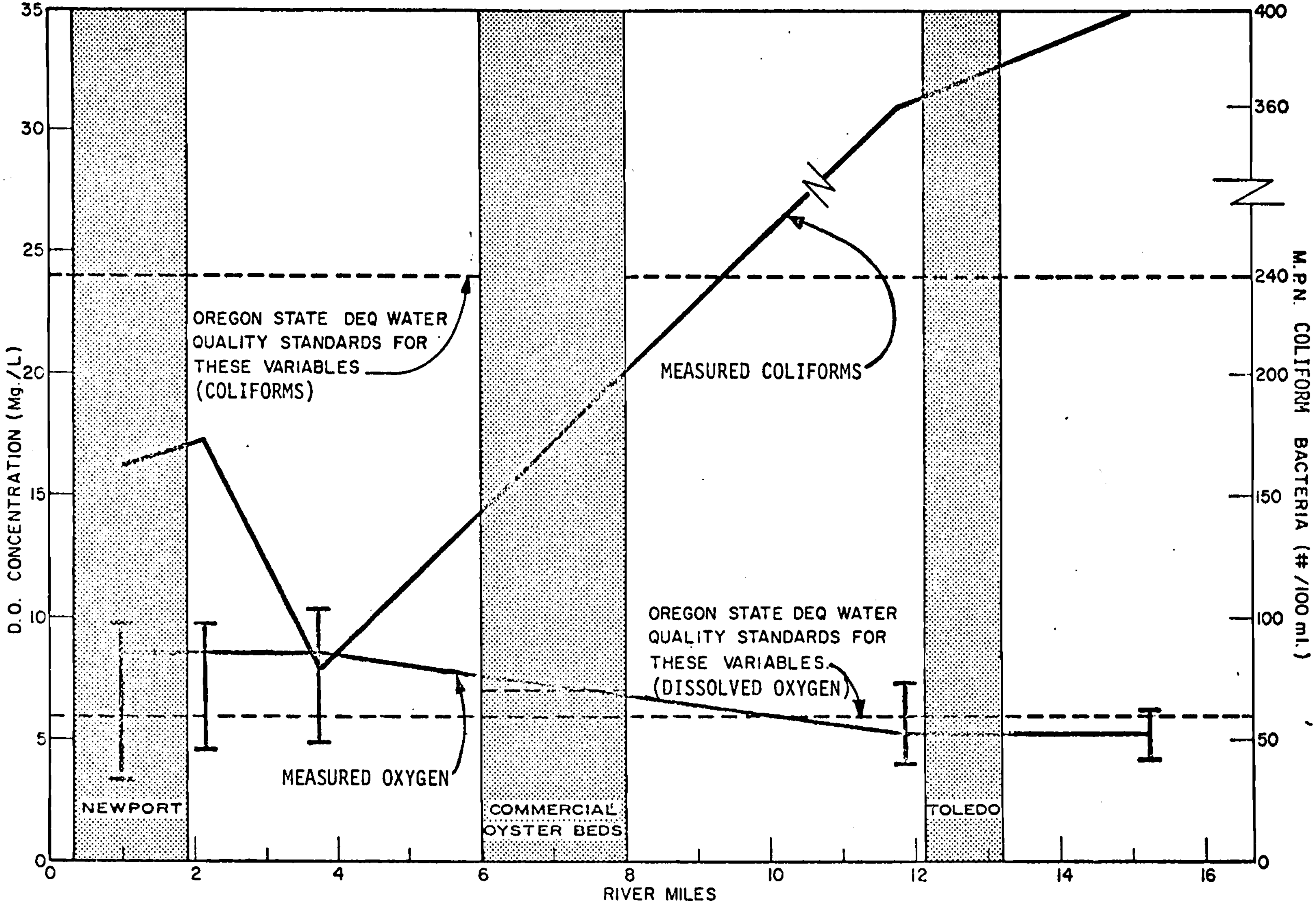

FIGURE 10. **SELECTED WATER QUALITY DATA FOR YAQUINA BAY AND RIVER**

Source: U.S. Army Corps of Engineers, Draft Environmental Impact Statement, Yaquina Bay and River, March, 1975.

however, and only limited numbers of measurements have been taken in some instances. These data, however, are limited to measurements of water taken from the surface or in the water column. The water column itself is not the only factor in estuarine water quality management which is of concern.

A recent study by Bella[32] indicates the importance of estuarine benthic systems in sound water quality management. They should not merely be treated as boundry conditions to overlying waters, but rather as systems of interacting components and processes with the larger estuarine systems. The sulfur cycle was singled out as being of major water quality importance in estuarine benthic systems. Through combinations of various factors, including relative inorganic and organic deposition rates, DO concentrations, sulfate concentrations, scour velocities and other factors, sediments can exibit various levels of free sulfides (H_2S, HS^-, $S^=$) which in turn can be correlated with the degree of pollution. Sites studied in Yaquina Bay (August, 1971) located at Sally's Bend (river mile 3.7) and Toledo (river mile 13) showed these sediments were very low in free sulfides, indicating high water quality and good productive potential, based on this analysis. Further field evidence showed that during late summer and early fall months, some locations tended to shift to benthic types more typical of polluted systems. The opposite is true in winter when reaction rates slow, dissolved oxygen is higher, sulfate concentration lower, and scour and inorganic desposition greater.

The chemical characteristics of bottom samples taken from five areas in Yaquina Bay and estuary were reported by EPA in 1971.[33] Four out of five of the samples proved to be above the maximum levels in

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[32] Bella, p. 1.

[33] U.S. Environmental Protection Agency, Office of Water Programs, Region X, Effects of Dredging on Water Quality in the Northwest (Seattle, July, 1971).

volatile solids and chemical oxygen demand (COD) allowable for water disposal of dredged materials. Greater than 10% volatile content is considered to cause a significant degradation of the benthic community. Two of the samples were also above the allowable levels for grease and oil. Dredged materials containing such levels of pollutants should be disposed of on land in properly constructed and operated sites. The one sample which was below the maximum allowable levels for water disposal in all parameters was from Toledo, upstream from the Georgia-Pacific Corporation. It was 94% sand as compared to other samples which were half sand or less, with higher concentrations of silt and clay.

In summary, Yaquina Bay and River water quality is generally good. However, accumulations of various pollutants have occurred in the sediments and periodic resuspension of these pollutants during dredging operations can have a harmful effect on the entire water column.

YAQUINA ESTUARY LAND AND WATER USE PATTERNS

The Yaquina Bay region has gained some noteriety for its pioneering effort in estuary planning, which resulting in its 1969 land and water use plan and the subsequent 1972 plan for marine development, designed to translate the initial planning into an action program. The prime mover in this effort was the Yaquina Bay Regional Planning Commission and their still active successor, the Yaquina Bay Task Force. The reason for the success of this effort was that local citizens played the principle roles. Another essential ingredient in this process was the intimate involvement of state and federal agencies who had mandated interest in Yaquina estuary. Such involvement not only provided technical expertise and a balance of interests, but also smoothed the way later for projects which were in consonance with the agreed-upon plan.

The Spectrum of Uses

The major uses that compete directly or indirectly for the coastal and estuarine resources of the Yaquina Bay area are categorized in Figure 11.[34] This arrangement serves to illustrate that the coastal zone is defined according to the frame of reference of the user, and that uses with overlapping areas of direct operations and/or ancilliary locations do and will compete for space. For example, if the demand for small boat moorages were projected to the year 2000 and space reserved for them on Yaquina Bay, it would be likely to preempt most other uses.[35]

According to Sorenson,[36] spatial competition, combined with three other factors produces an overview of the conflicts and resources degradation problem. These factors are (1) the scarcity of the resource commodity in question, (2) hydrologic and ecological processes and (3) adverse aesthetic impact and amenity dissatisfaction. A fourth factor which contributes to this problem and in fact, often prevents its recognition, is that the development of these resources is incremental in nature. We fail to realize at the time that scarce resources are being irreversibly committed. Incremental growth receives its impetus from the common

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[34] The dimensions of the coastal zone might be described as a band of continuous length having a width that varies with the utilization of a particular coastal resource. In figure 11, upper case letters and vertical bars refer to areas of DIRECT operations and lower case letters denote ANCILLIARY operations.

[35] The Yaquina Bay Marine Development Plan, a ten-year program, had as one of its major goals the elimination of as much spatial conflict as possible. Of particular concern was the Newport bayfront, where commercial fisheries, tourism and sports boating interests all collide.

[36] Jens C. Sorensen, A Framework for Identification and Control of Resource Degradation and Conflict in the Multiple Use of the Coastal Zone (University of California, Berkeley, June, 1971) p. 7.

Figure 11. ARRANGEMENT OF USES ACROSS THE YAQUINA BAY REGION COASTAL ZONE.

Use	DEEP OCEAN	CONTINENTAL SHELF	SHORELINE	SHORELAND	COASTAL UPLANDS	COASTAL WATERSHEDS
	Over 100 fathoms	100 to 1 fathom	1 fathom to high water	high water to limit of immediate access	limit of immediate access to ridgeline	over coastal ridgeline
COMMERCIAL FINFISHING		breakwaters, channels	harbors, fish nursery	processing plants		anadromous nursery
SHIPPING		breakwaters, channels	harbors, shipyards	terminals, processors	highways railroads	channels, harbors
COAST GUARD OPERATIONS	maneuvers, firing range	breakwaters, channels	harbors drydock	support facilities	support facilities	
MARINE RESEARCH	exploration sampling	exploration sampling	docks research	laboratories		
SPORT FISHING, BOATING		breakwaters, channels	marinas, fish nursery	parking, concessions		anadromous nursery
WATER CONTACT SPORTS		underwater parks	swimming, surfing, scuba.	parking, concessions	parking, picnic, camping	
WASTE DISPOSAL	dumping areas	dumping areas, outfalls	landfill, outfalls	sewage plants	landfill, septic tanks	outfalls, landfills
MARINAS		channels, breakwaters	docks, channels	concessions, parking	storage, sales	
SHELLFISHING			docks, racks, fencing	processing plants		estuarine food supply
SALMON CULTURE	growth areas	growth areas	intake water, effluent discharge	rearing ponds, support buildings		hatchery
NATURAL RESERVE						
WATERFOWL HUNTING						
CLAMDIGGING				parking		
BEACHCOMBING				parking		
COMMERCIAL SERVICES		outfalls,	pilings, docks, fill	parking, signs, highways.	highways, signs, utility.	outfalls
RESIDENTIAL		outfalls,	pilings, docks, fill	parking, roads, utility.	roads, utilities	outfalls, septic tanks
COMMUNICATIONS	undersea cables	undersea cables	towers, wires, antennae	towers, wires, poles	tower, wires, poles	
LNG IMPORT TERMINAL	tankers	tankers, channels	channels, docking area	tank, pipelines	pipelines	
PICNICKING-CAMPING			trails	parking, trails, roads	service facilities	
PLEASURE DRIVING			bridges, dikes, fills	turnouts, picnic areas	turnouts, picnic areas	
HIGHWAYS			bridges, dikes, fills	road cuts, fills	road cuts, fills	
LUMBER PROCESSING	bulk carriers	bulk carriers, channels	channels, harbors	terminals, cranes	highways, railraods	channels, harbors
AGRICULTURE			dikes	dikes	fencing, farm structures.	water diversion
FOREST PRODUCTS INDUSTRY			soaking basins, outfalls.	pulp & lumber mills	mills, camping roads	pulp mills, logging roads

(adapted from Sorensen, A Framework for Identification and Control of Resource Degradation and Conflict in the Multiple Use of the Coastal Zone, June, 1974) notion that all growth is good, as long as it provides new jobs and money. A quick glance at the spectrum of uses provides a perspective which shows that while one use may increase the "goods" of a community, it may have a net adverse effect through conflicts with one or more other uses. This is particularly true of the shoreline and shoreland, where almost all uses have direct or ancilliary operations. These factors were recognized during development of the Yaquina Bay Marine Development Plan and played an important role in the separation of conflicting uses to different areas of the estuary.

General Land Use and Ownership

Figure 12 shows the pattern of land use in the Yaquina Bay area in 1969. Some growth has occurred since that time, paricularly in the Newport area, but the general pattern is the same. The heaviest industrial concentration is in Toledo, the center for wood processing in the mid-coast area. Commercial concentrations are within the major residential areas of Newport and Toledo. There is little agricultural development in the Yaquina River basin. Public and semi-public uses are scattered throughout the area.

The general ownership pattern that exists in the Yaquina Bay area at present shows that most of the land in the more rugged forested areas is owned either by large timber companies or the federal government. The large private non-timber company ownerships tend to be scattered with some concentration fairly close to the Yaquina River near Boone Slough. Smaller private holdings predominate along state highways, immediately adjacent to the Yaquina River, and within and near

Figure 12.

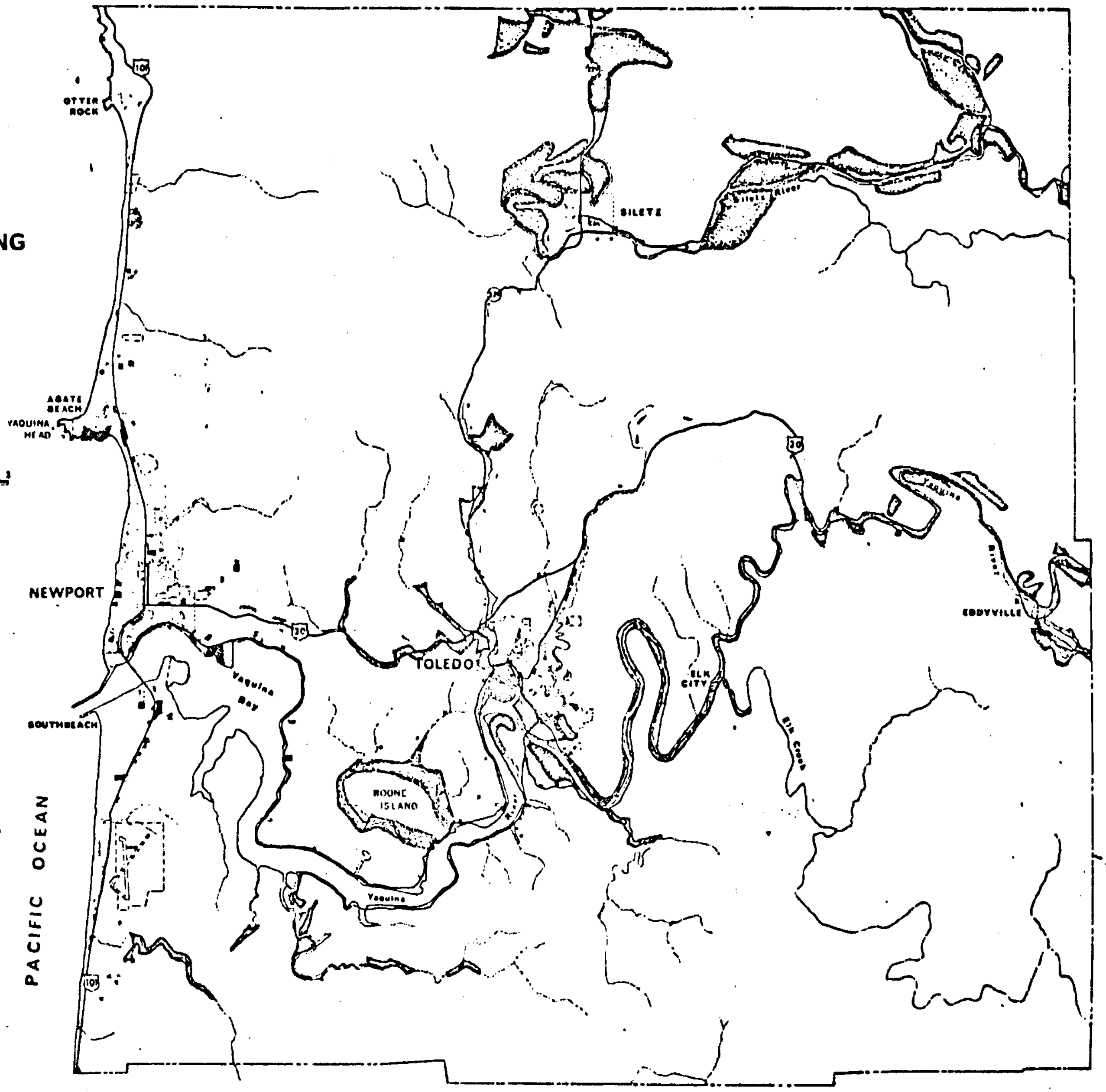
YAQUINA BAY
PLANNING AREA

GENERALIZED EXISTING LAND USE MAP 1969

- RESIDENTIAL
- COMMERCIAL
- INDUSTRIAL
- AGRICULTURAL
- PUBLIC OR SEMI-PUBLIC
- FOREST OR VACANT

Scale in Miles

Source: Preliminary Land Use Plan for the Yaquina Bay Area, 1969.



the cities of Newport and Toledo and the communities of South Beach and Agate Beach. The possible growth directions of both Newport and Toledo are dictated in large part by the extent of the small ownership pattern beyond the city limits. Figure 13 shows the pattern of public, large private and small private ownerships in the area.

Commercial Fishing

Newport is the mid-coast center for commerical fishing activity. Newport is home to a large fishing fleet with 518 boats licensed as being permanently moored in Newport in 1975. About 550 transient fishing boats use port facilities as well. Numerous fish processing plants, both large and small, are located on the bayfront. The landed value of the food fish catch at Newport was 13 million pounds worth $5 million in 1974.[37] Table 5 shows the breakdown and value of the catch over several years. Commercial landings from the estuary itself are fairly limited with oysters, clams and crabs the main species.

Aquaculture

Oysters are grown commercially from river mile 6 (Riverbend) upstream to river mile 8. While 1800 acres of Yaquina Bay are considered suitable for oyster culture, only 411.75 acres are leased.

Coho, chum and chinook salmon and rainbow trout are raised in ponds at Southbeach to the west of the OSU Marine Science Center by Oregon Aqua-Foods, Inc. They also operate a salmon hatchery at about mile 7 of Wright Creek. It is expected that releases of fingerlings could substan-

[37] Fish Commission of Oregon, Personal Communication, September 25, 1975.

Figure 13.

YAQUINA BAY
PLANNING AREA

LAND OWNERSHIP MAP 1968

- F FEDERAL
- S STATE
- Co COUNTY
- C CITY
- S.D. SPECIAL DISTRICTS
- LARGE PRIVATE OWNERSHIPS
- LARGE PRIVATE TIMBER COMPANY HOLDINGS
- SMALL PRIVATE OWNERSHIPS

Source: Preliminary Land Use Plan for the Yaquina Bay Area, 1969.

Scale in Miles: 0, ½, 1, 2

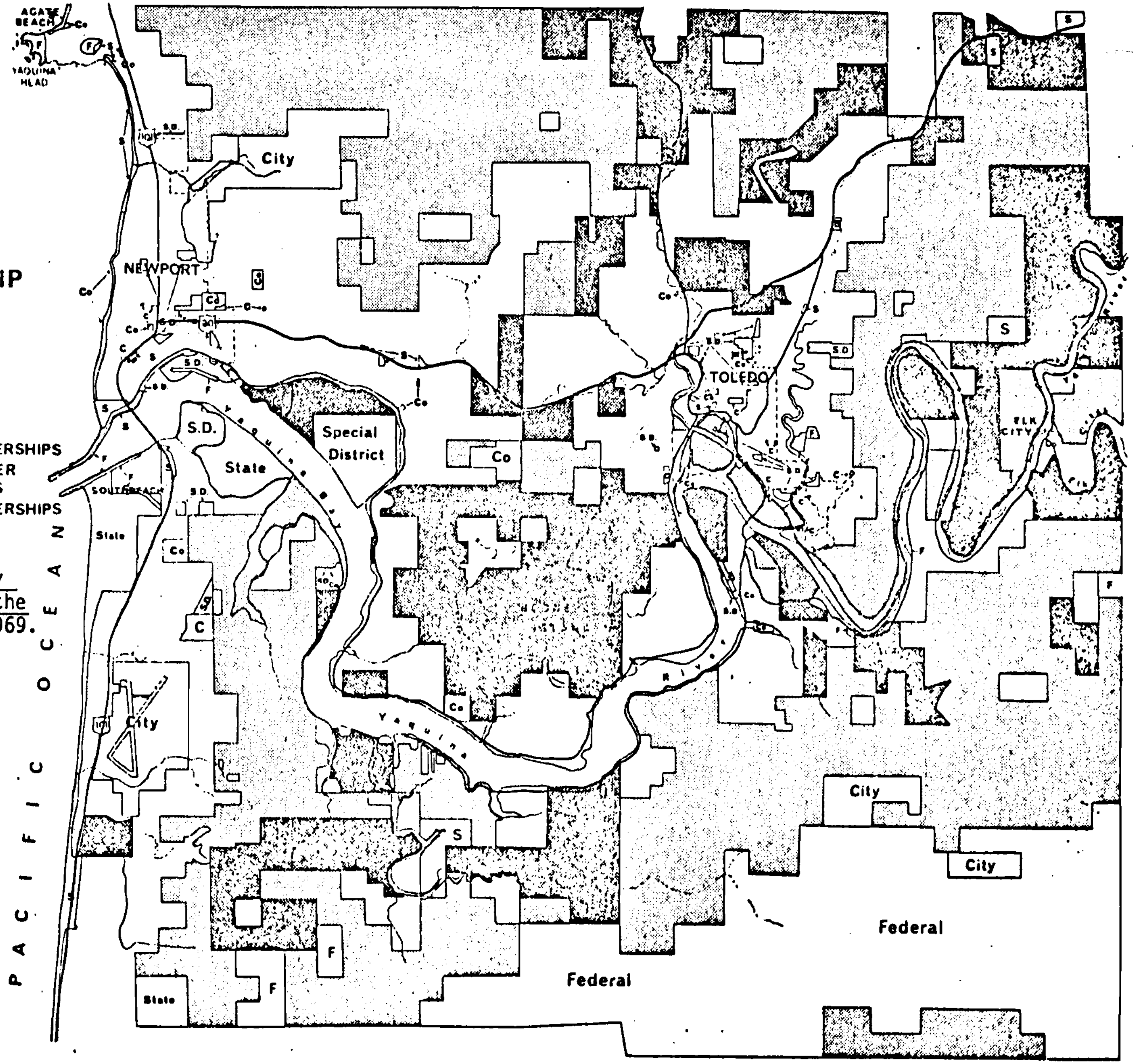


Table 5.
Port of Newport Fish and Shellfish Landings and Value at the Fisherman's Level 1970-1974.

Year	Species	Pounds	Value
1970	Chinook	285,503	$ 211,000
	Coho	2,869,829	1,485,000
	Sturgeon, green	5,927	--
	Crabs	3,150,766	788,000
	Shrimp	3,171,867	381,000
	Albacore	2,136,902	587,000
	Groundfish	2,155,330	162,000
	Oysters	47,530	56,000
	Total	13,824,996	$3,670,000
1971	Chinook	104,876	$ 63,000
	Coho	1,695,469	531,000
	Sturgeon, green	9,599	1,000
	Smelt	350	--
	Pinks	1,848	1,000
	Crabs	3,624,105	1,087,000
	Clams	2,039	--
	Shrimp	3,601,879	431,000
	Albacore	1,027,813	311,000
	Groundfish	2,401,098	198,000
	Oysters	39,560	81,000
	Total	12,447,184	$2,692,000
1972	Chinook	193,783	$ 137,000
	Coho	1,095,714	508,000
	Sturgeon, green	15,637	1,000
	Smelt	750	--
	Pinks	15	--
	Crabs	1,263,913	536,000
	Clams	57	--
	Oysters	36,568	107,000
	Shrimp	7,333,113	990,000
	Sand Shrimp	40	--
	Albacore	3,572,764	1,215,000
	Groundfish	2,596,874	247,000
	Total	16,109,228	$3,741,000
1973	Chinook	952,493	$ 856,000
	Coho	1,712,495	1,241,000
	Sturgeon, green	6,148	--
	Sturgeon, white	171	--
	Pinks	108	--
	Crabs	327,355	187,000
	Shrimp	6,500,542	1,430,000
	Albacore	2,667,723	1,139,000
	Groundfish	3,531,150	428,000
	Oysters	58,776	157,000
	Total	15,756,961	$5,862,000
1974	Chinook	448,820	$ 426,000
	Coho	2,301,323	1,497,000
	Sturgeon, green	2,083	--
	Smelt	430	--
	Pinks	37	--
	Crabs	912,618	574,000
	Clams	398	--
	Shrimp	4,386,054	973,000
	Albacore	2,344,296	961,000
	Groundfish	2,587,209	409,000
	Oysters	55,144	156,000
	Misc.	134	--
	Total	13,038,546	$4,996,000

Source: Oregon Fish and Wildlife Commission, Unpublished Data, September, 1975.

tially increase the salmon runs through the Yaquina estuary, thereby providing increased commercial and recreational fishing opportunities in addition to a profitable aquaculture venture.

Recreation

The Yaquina Bay area is one of the major recreation centers on the coast. Major recreational activities include sightseeing, shore and boat fishing, clam digging, pleasure boating, camping, picnicing, nature-viewing, beach-combing and visiting the aquarium and museum at the OSU Marine Science Center.

Developed state parks in the area receive heavy use, particularly Yaquina Bay State Park located on the north side of the mouth of Yaquina Bay, providing a view point, picnic facilities and beach access. Another area which receives heavy use but is undeveloped is the south jetty and adjacent beach area, where shore-fishing, sun-bathing, wading and SCUBA diving are popular.

The bayfront of Newport is a popular tourist center, with many gift shops, seafood restaurants and retail stores, and an aquarium. In addition, there are over 800 small boat moorages here and several launch facilities,[38] all of which contribute to somewhat frantic congestion during summer months.

The public service area at the OSU Marine Science Center attracts close to 300,000 visitors annually, including over 300 school groups. The center features an aquarium, a handling pool, educational exibits and various displays. In addition, films on marine subjects are offered daily.

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[38] Port of Newport, Personal Communication, September 16, 1975.

The major attraction offered by Yaquina Bay and the adjacent coastal ocean area is sports fishing. Several charter fishing services are offered on the Newport bayfront. Boat and shore anglers, clam diggers and skin divers turnout in great numbers, particularly during summer months. In 1971, 217,800 hours of effort were expanded in over 100,000 recreation trips, yeilding a harvest of 626,500 animals, broken down by category as shown in Table 6. Data for this table was taken from a resource use study done by the Fish Commission of Oregon,[39] one of a series on Oregon estuaries. This data, in combination with other available information from different years, and species life cycle information could be used to determine the possibility of overfishing certain estuarine species. If such a problem exists, it will be compounded in the future, as recreational facilities on the estuary increase. Excessive pressure on bay fisheries may deplete breeding stocks, add to congestion and reduce the success/effort ratio, thereby lowering the value of the recreational experience to the individual.

Table 6

Number of Angler Trips, Hours of Effort and Animals Caught, Yaquina Bay 1970-71

	No. Trips	Angler Hours	Fish	Crab	Clams	Misc	Total
Boat	27,554	93,577	53,152	40,865	0	0	94,017
Shore	47,333	86,039	78,939	11,467	0	0	90,406
Tidelands	24,347	36,332	6	637	402,314	37,427	440,374
Diving	1,453	1,853	1,526	99	84	10	1,719
GRAND TOTAL	100,687	217,801	133,623	53,068	402,398	37,427	626,516

SOURCE: Yaquina Bay Estuary: A Study in Resource Use
Fish Commission of Oregon. February, 1974.

39 Tom Gaumer, Darrell Demory and Lamons Osis, Yaquina Bay, Oregon: A Study in Resource Use, Fish Commission of Oregon, Division of Management and Research, November, 1973, p. 23.

Deep-water Shipping

Newport is one of three coastal deep-water ports and the smallest in terms of shipped tonnage. The current trend is toward a reduction in traffic, which consists primarily of exported logs and processed wood products. No commodities are imported at present. Most of the logs are shipped out of Newport Terminals, located on McLean Point, to destinations in Japan. Forest products including lumber and paper are barged downriver from Toledo for export. The outlook for increased deep-water shipping activity is bleak except for the LNG project, which will increase traffic by two to three ships per month. The deep channel also serves the ocean-going research vessels which are based at the Marine Science Center.

Marine Research and Education

Located on the south shore of Yaquina Bay, the OSU Marine Science Center is the focal point of marine-related research and education on the Oregon coast. The center serves the research needs of many departments at OSU. Student research is also conducted and a full range of marine coursework is available as well. OSU research projects involve fish and mollusc aquaculture and genetics, marine pollution, pathology, meterology, ecology and algology. The federal Environmental Protection Agency maintains a marine field station at center, conducting research on the assessment of ecological alterations. The Fish and Game Commission conducts research concerning Oregon's Commercial Fisheries in a separate building in the complex. In addition, the OSU Sea Grant-Supported Marine Advisory Program has headquarters at the center, directing their overall program and participating in public service and education projects there. The center continues to expand with the philosophy being to develop it into a major regional facility for instruction, research and public services in the marine sciences. There are presently over 100 full-time employees located at the center, with a total payroll of about $1,000,000.

Residential Development

Two of the largest population centers in Lincoln County are located on Yaquina estuary, namely Newport and Toledo. Further residential development will probably occur first on small private holdings, which, as Figure 13 shows, control the majority of land adjoining the estuary, particularly on the north shore. Some of the larger private holdings may also have potential for planned developments, both permanent and recreational in nature. An example of such a development is the Embarcadero Hotel, Condominium and Marina in Newport.

Other Estuary Uses

Other uses of less spatial significance in Yaquina estuary include U.S. Coast Guard operations, hunting, highway construction, agriculture and forestry. This is not to imply that these uses are not important. The regional economy is highly dependent on the forest industry which is centered in Toledo. Much of the coastal watershed is managed for timber production with a consequent impact on river water quality, from both increased siltation, raised water temperatures and log storage. The primary agricultural lands are along the river and Boone and Nutes Sloughs, west of Toledo.

Projected Land Use and Development

The zoning ordinances adopted by the City of Newport and Lincoln County reflect the planning areas adopted by the Yaquina Bay Regional Planning Commission. The zones reflect to a large degree existing uses and trends. Bay area adopted zoning is depicted in Figures 14A-14E, showing residential, commercial, industrial, natural resources and composite use plans.

Figure 14A

YAQUINA BAY
PLANNING AREA

PRELIMINARY LAND USE PLAN

SMALL AREA MAP

RESIDENTIAL

- SINGLE-FAMILY RESIDENTIAL
- MULTI-FAMILY RESIDENTIAL
- RECREATION RESIDENTIAL
- RURAL RESIDENTIAL

Source: <u>Preliminary Land Use Plan for the Yaquina Bay Area</u>, 1969.

Scale in Miles
0 ½ 1 2

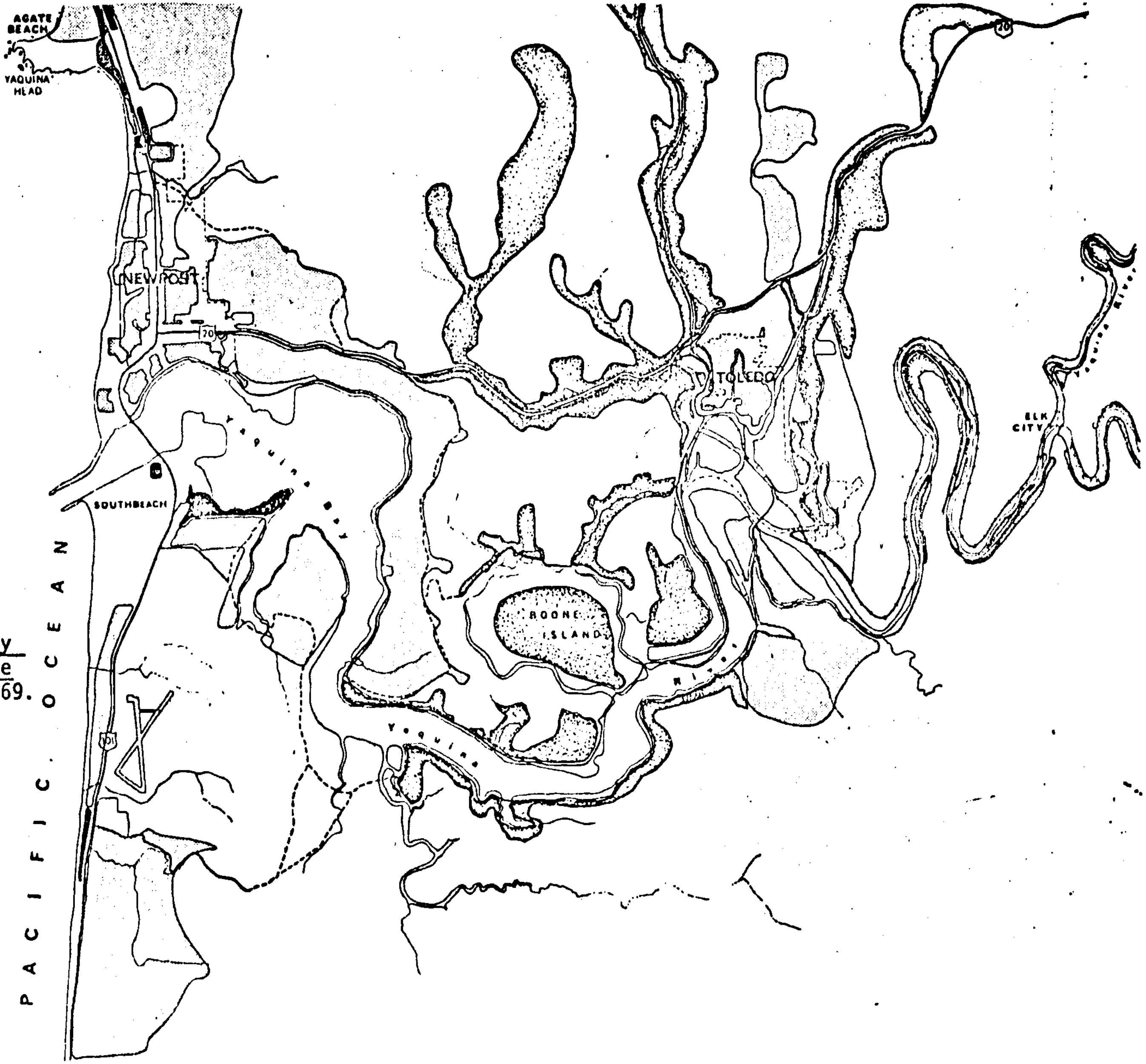


Figure 14B

YAQUINA BAY
PLANNING AREA

PRELIMINARY LAND USE PLAN

SMALL AREA MAP

COMMERCIAL

- TOURIST COMMERCIAL
- RETAIL COMMERCIAL
- GENERAL COMMERCIAL
- MARINE COMMERCIAL
- WATERFRONT COMMERCIAL
- RURAL COMMUNITY

△ MARINE COMMERCIAL
GENERAL LOCATION FOR FUTURE DEVELOPMENT

Source: Preliminary Land Use Plan for the Yaquina Bay Area, 1969.

Scale in Miles
0 ½ 1 2

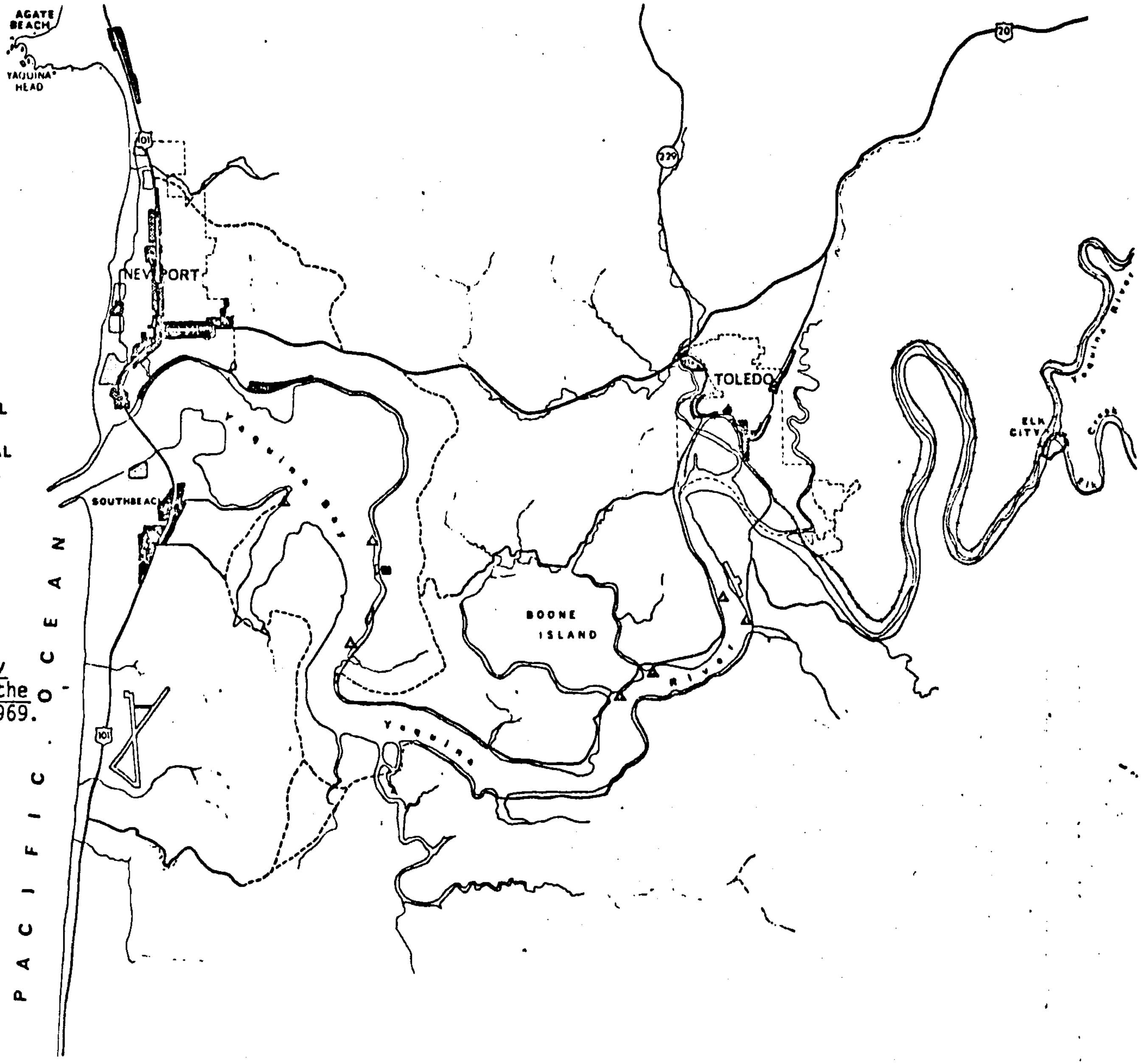


Figure 14C

YAQUINA BAY
PLANNING AREA

PRELIMINARY LAND USE PLAN

SMALL AREA MAP

INDUSTRIAL

- MARINE INDUSTRIAL
- LIMITED INDUSTRIAL
- GENERAL INDUSTRIAL
- PLANNED MARINE AND RECREATIONAL

△ GENERAL LOCATION FOR FUTURE DEVELOPMENT

Source: Preliminary Land Use Plan for the Yaquina Bay Area, 1969.

Scale in Miles
0 ½ 1 2

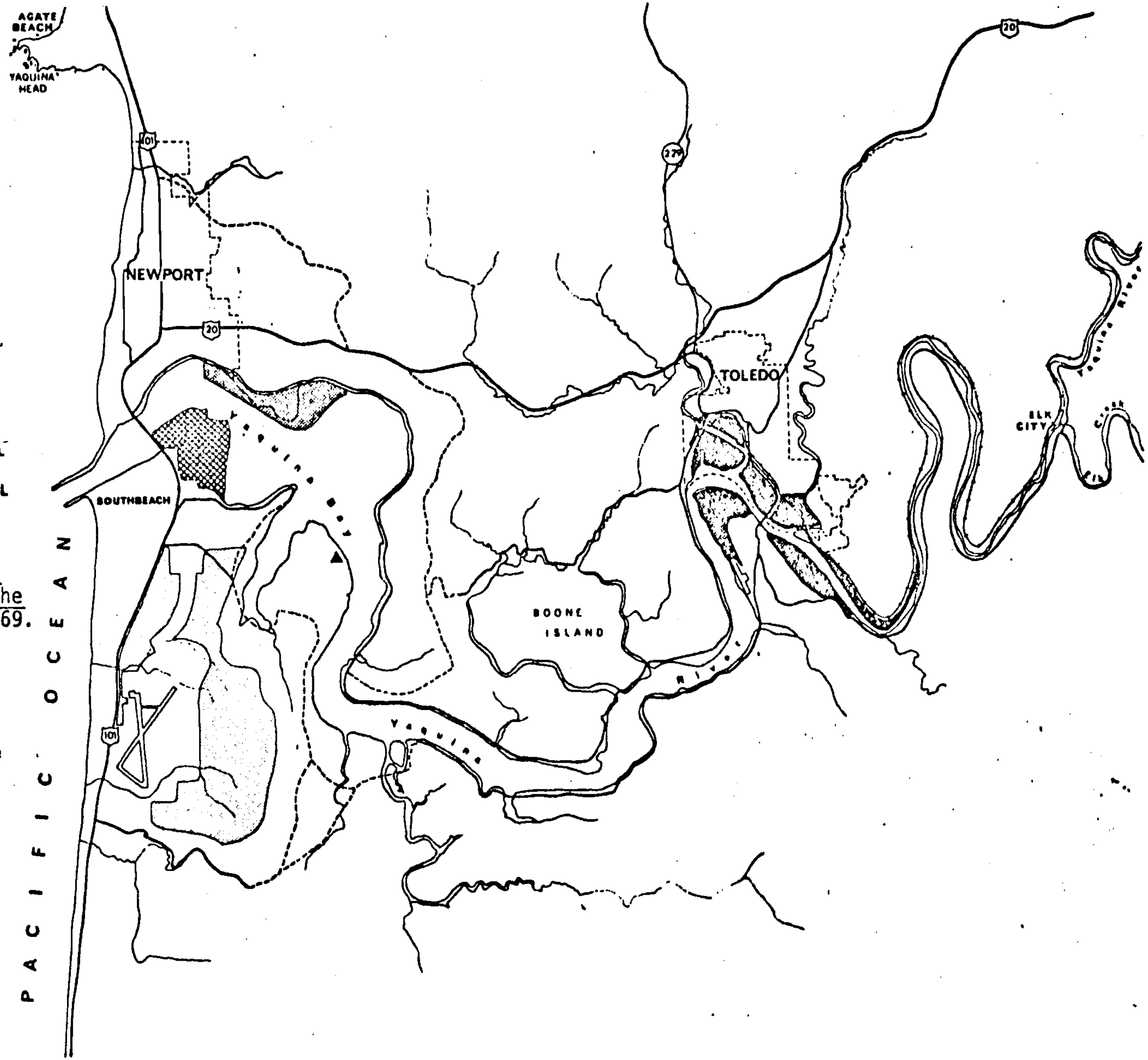


Figure 14D

YAQUINA BAY
PLANNING AREA

PRELIMINARY LAND USE PLAN

SMALL AREA MAP

NATURAL RESOURCE AND PUBLIC AREAS

- ROCK DEPOSIT
- TIDELAND
- MARSHLAND
- DIKELAND
- MARINE PRODUCTION
- RECREATION
- PUBLIC
- OPEN

△ RECREATION
GENERAL LOCATION FOR FUTURE DEVELOPMENT

Source: Preliminary Land Use Plan for the Yaquina Bay Area, 1969.

Scale in Miles
0 ½ 1 2

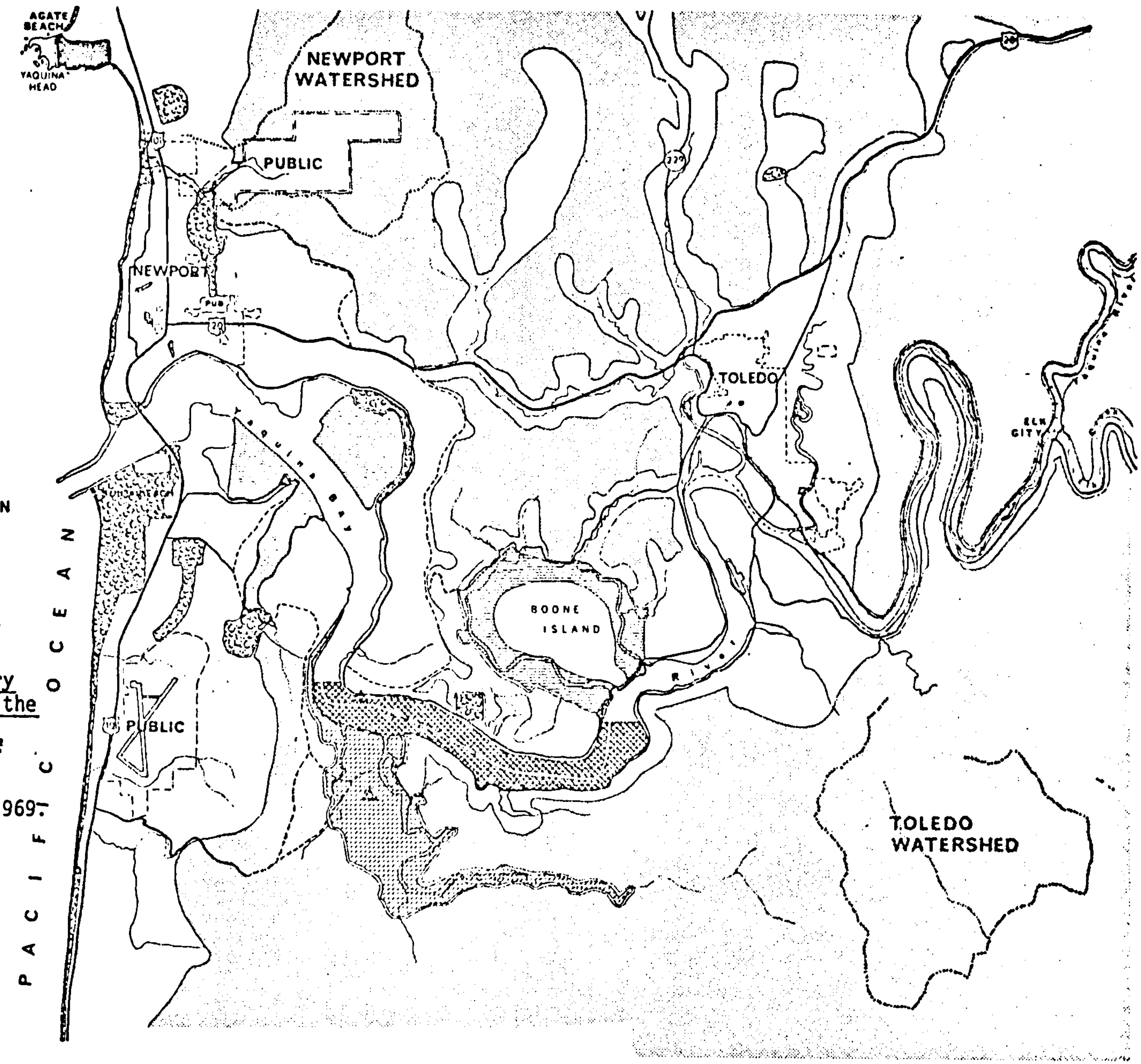


Figure 14E

YAQUINA BAY
PLANNING AREA

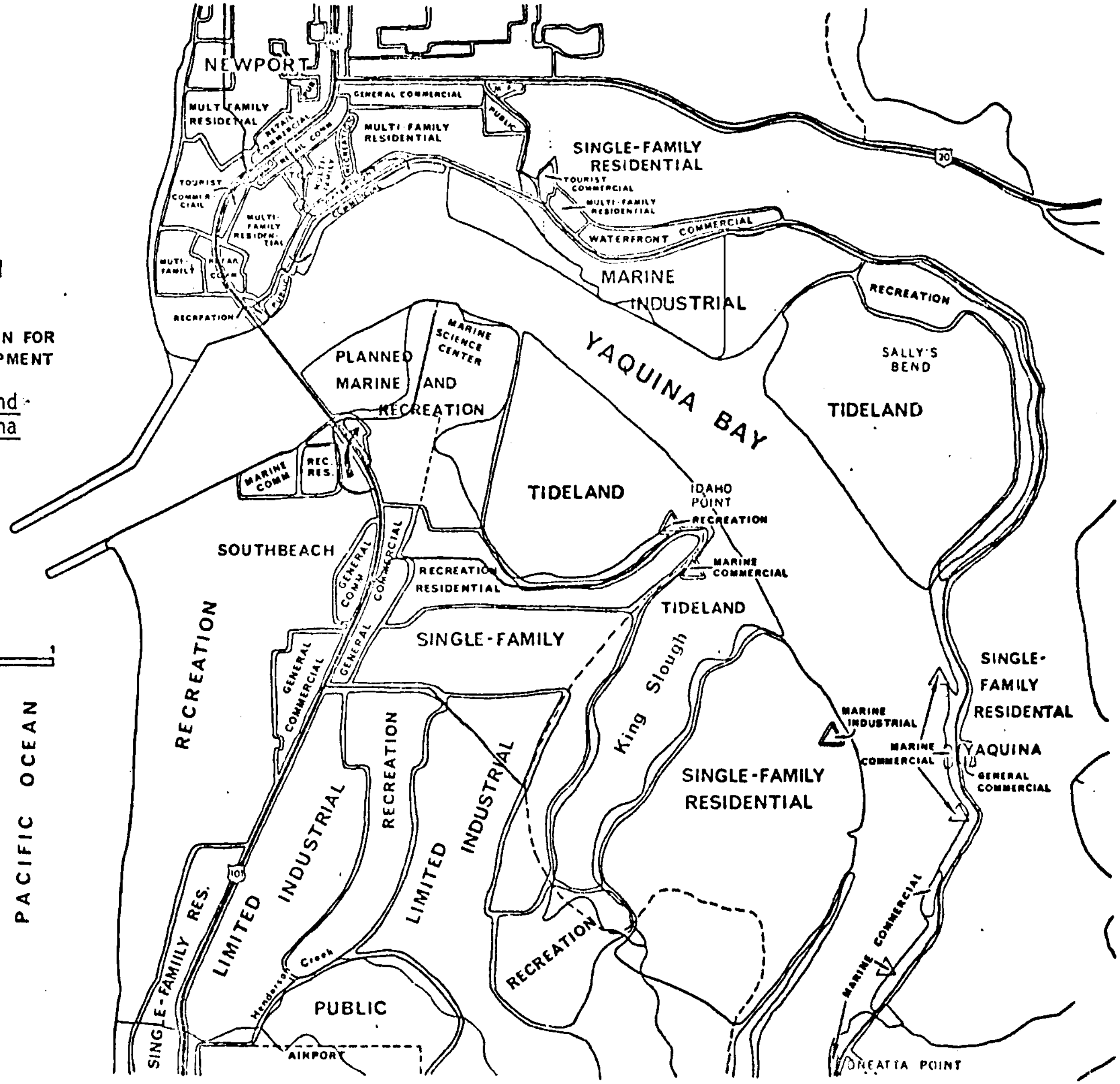
PRELIMINARY LAND USE PLAN

BAY AREA MAP

△ GENERAL LOCATION FOR FUTURE DEVELOPMENT

Source: Preliminary Land Use Plan for the Yaquina Bay Area, 1969.

Scale in Miles: 0 ¼ ½ ¾ 1



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The Yaquina Bay Marine Development Plan identified twenty four projects which were designed to fit the land use criteria as adopted above. The plan was prepared in three phases.

First, marine-related industry, tourism and recreation were identified as the industries that demonstrated the most potential for future assured growth.

Second, development policies, guidelines and actions were recommended which located assured growth industries in proper land use areas. The Yaquina Bay Task Force adopted six policies to:

1. Maintain and enhance the entire Yaquina Bay watershed with the estuary as its central and most valuable resource,

2. Encourage the development of economic growth industries in the region,

3. Protect and preserve the marine related natural resources of the bay as a major social and economic value to the region, the state and the nation,

4. Establish and support the development objectives of the four Yaquina Bay sub-areas (The Bayfront, Southbeach, Upriver, Toledo),

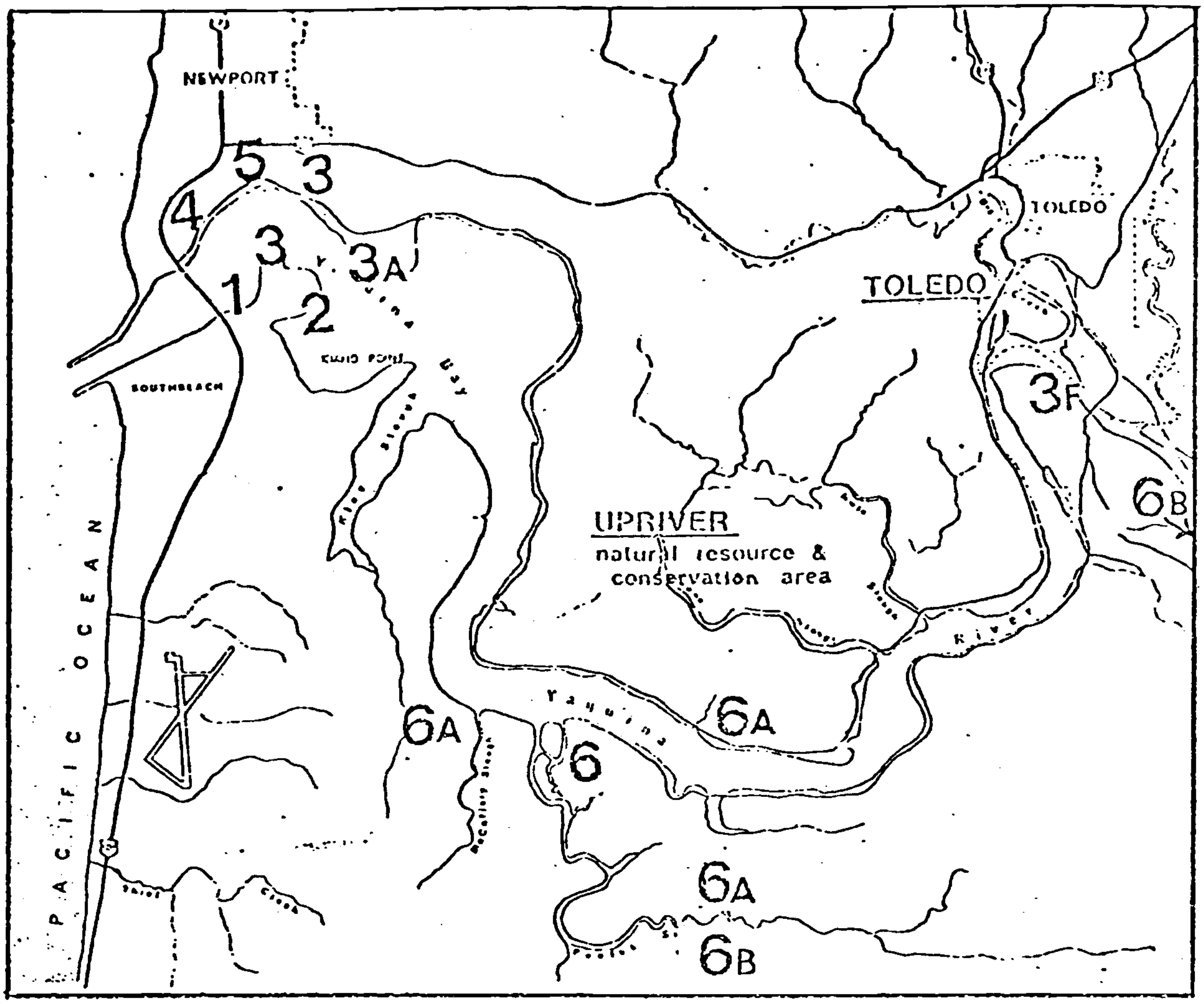
5. Adopt interim criteria to evaluate the compatibility of proposed projects with the development objectives of each sub-area, and

6. Provide the coordination necessary to insure that all agencies with control or approval responsibilities within the Yaquina Bay area are aware of the above goals and working toward their implementation.

Phase three of the program resulted in specific policies to guide future marine and recreational development in the Yaquina Bay area, and the citing of specific projects as potential candidates for federal financial assistance. All twenty-four projects identified in the plan are shown on Figure 15.

Development according to the action program has progressed steadily, with two of the largest projects on the bay, one of which was planned (Southbeach Marina-Hotel convention Center) and the other not (LNG import terminal), just getting underway.

Figure 15. Yaquina Bay Marine Development Plan



MARINE DEVELOPMENT PLAN

1. SOUTHBEACH MARINE-RECREATION COMPLEX

   1A. Utility construction across Bay and Mainline Extension.
   1B. Site improvements.
   1C. Marina development(wet moorages).
   1D. Dry boat storage.
   1E. Marine-Oriented lodging and meeting facilities.
   1F. Marine-recreation-related commercial facilities.
   1G. Marine user-oriented travel trailer court.

2. O.S.U. MARINE SCIENCE CENTER DEVELOPMENT

   2A. Extension offices.
   2B. Physical oceanography building.
   2C. Fisheries and EPA wing.
   2D. Access roads.

3. IMPROVED COMMERCIAL FISHING FACILITIES

   3A. Marine Railway and Boat repair.
   3B. Gear sheds.
   3C. Crab pot storage.
   3D. Dry boat storage.
   3E. Wet moorages.
   3F. Boat building facilities

4. REVOLVING FUNDTO RESERVE WATERFRONT LAND FOR MARINE-ORIENTED USES

   4A. Land aquisition, deed and lease restrictions, relocation activities.

5. CIRCULATION AND PARKING IMPROVEMENTS.

   5A. Road extension of 13th Street to Canyon Way.
   5B. Parking off the 13th Street Extension.
   5C. Connection of US 101 and US 20 to Bay Blvd. via Johnson Creek, and parking.
   5D. Parking on inland side of Bay Blvd. between Port docks 3 and 5.

6. MARINE RESOURCE DEVELOPMENT

   6A. Oyster and Clam Factory.
   6B. Salmon rearing.

Source: Yaquina Bay Task Force, Yaquina Bay Marine Development Plan, August, 1972.

SECTION 2

LNG PROJECT ECONOMIC IMPACT

Regional Impact and LNG Cold Utilization

Northwest Natural outlined some of the benefits accruing to the local area in their 1974 siting consequences report[40] prepared for the Yaquina Bay Task Force. These benefits still apply if it is assumed that a new supply of LNG will be obtained. These included a $10 million increase in the Lincoln County Tax base, various construction period benefits, about 10 new permanent jobs created for the operating staff, and a good possibility of having most of a 20 man ship crew reside in Newport. Provisioning of the ship and bar pilot services would also offer increased income for the area. The much needed gas supply would benefit all Oregon users equally since the gas is to be delivered into the main distribution system.

A very favorable aspect of the project for the Port of Newport would be that regular use of the harbor by a deep-draft vessel would provide justification for continued maintenance dredging of Yaquina Bay channel and harbor by the U.S. Army Corps of Engineers. With continuing decline of other deep water shipping activity[41], mostly logs, lumber and paper, this new venture would provide Newport with a deep-water port for the life of the project. As such, it would be more attractive to industry needing such accommodations and allow the Port to guarantee some stability that is currently questionable.

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40 Northwest Natural Gas Company, Siting Consequences of the Newport LNG Receiving Terminal (Newport, Oregon, April 5, 1974).

41 John Savage, Export Shipping Developments at Newport, Oregon: An Overview (Department of Economics, Oregon State University, June, 1975), p. 2-5.

A recent report [42] for the Yaquina Bay Shipping Council indicated that the outlook for attracting additonal deep-water shipping to Newport is bleak for a number of reasons. Among these are a lack of commodities, poor transportation linkages to and from market and production areas, and a general inability to detour business away from the larger, more diversified ports such as Portland. Because of this, Newport, and other small ports as well, can not afford to invest the necessary capital to become competitive.

The LNG project offers the potential for induced development which may bolster the outlook for Yaquina Bay shipping and development through utilization of LNG cold energy which is available upon vaporization of the liquid gas.

Production of the extremely cold (-259°F) LNG consumes about 14% of the feed natural gas as liquefaction energy; this should be the maximum potential energy which could be recovered using LNG cold. Because refrigeration power consumption becomes greater as temperatures lower, the use of LNG cold should be aimed at processes requiring these very low temperatures.

The Port of Newport, in anticipation of LNG cold availability, has received funding from the Pacific Northwest Regional Commission to investigate the feasibility of private industry utilizing this energy. The basic goal of the project is to identify, evaluate, and recommend industries which can economically utilize LNG revaporization energy and to develop industry, market, and economic information that can be used by the Port of Newport to approach private investment decision makers

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[42] _Ibid._, p. 8.

relative to locating in the Port area.[43] Martech Co., of Portland, a private consultant, recently received the contract and should have a report ready by mid-December.

Some examples which appear to have potential include cold storage, ice-making, food freezing, and cryogenic gas manufacturing. All of these would have a significant impact on the port, particularly the fishing and fish processing industries, which are currently limited by cold storage and ice-making capacity. The Port manager, Fred Weakly states that "Newport will become the fish fillet capital on the coast."[44]

Northwest Natural engineers indicate that a minimum base load of 30 million cubic feet per day of gas would require 190 million Btu of energy per day for the revaporization process. Using a conversion value of 200 Btu per minute per refrigeration ton, this equates to an available 660 tons of refrigeration per day. At maximum gas output of 50 MMcF of gas per day, this would be increased to 1100 tons per day. Because of various engineering economy and flexibility considerations, Northwest planned to make available a maximum of about 500 refrigeration tons per day.[45] Even this figure may be high, according to the Northwest Natural LNG project manager. Regardless of the amount finally settled upon, a considerable savings could be realized in both utility costs to LNG cold energy users and in gas conserved by Northwest Natural in the revaporization process. A possible plan for the cold energy recovery process is shown in Figure 16. The amount of LNG going through the heat exchanger would vary depending on user needs, but never more than about half total

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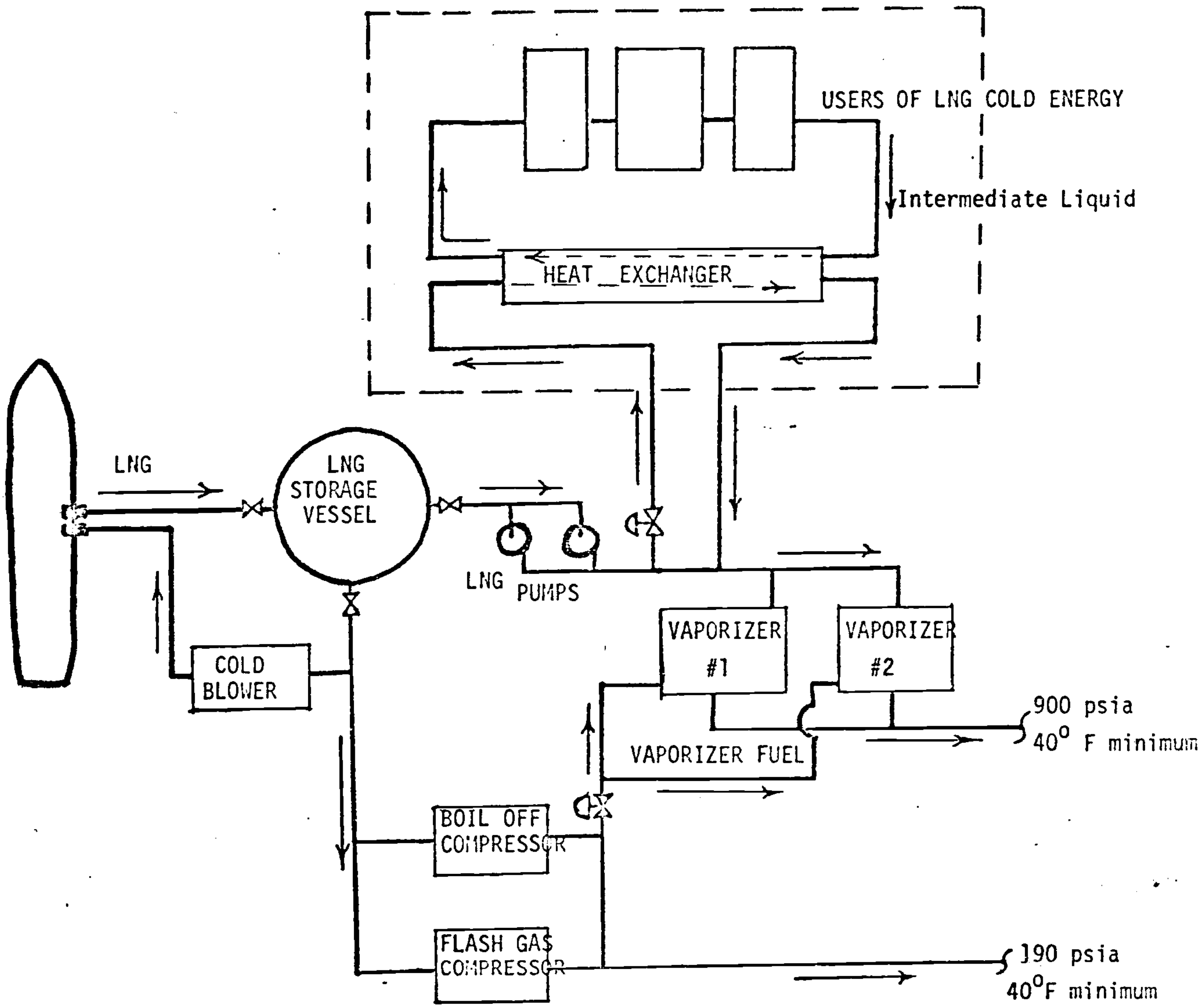
[43] Martech Company, Economic and Marketing Study for the Utilization of LNG Revaporization Energy at the Port of Newport (unpublished research proposal), August, 1973, p. 3.

[44] Gazette Times (Corvallis), "Port Manager is Elated by Passage of Bond Issue," June 19, 1975.

[45] Northwest Natural Gas Company, Progress Report on LNG Project, April, 1975, p. 3.

FIGURE 16 (Adapted from NWNG report, "Siting Consequences of LNG Import Terminal")



FLOW DIAGRAM

NORTHWEST NATURAL GAS COMPANY LNG IMPORT TERMINAL, NEWPORT, OREGON
also depicting
ASSOCIATED DEVELOPMENT UTILIZING LNG COLD ENERGY VIA HEAT EXCHANGE

LNG tank output, since Northwest Natural would require that the mixture entering the vaporizers still be in liquid phase.[46] A better determination of LNG cold energy availability and the exchange process should be forthcoming as Martech Company develops their study of cold utilization.

LNG cold utilization has been a reality in Japan since 1971.[47] A one million cu. ft., five story cold storage plant, which operates at temperatures from -95°F to -122°F, uses 96 refrigeration tons of LNG cold energy per day, less than 20% of what Northwest Natural is willing to provide in the revaporization process. They use an additional 192 refrigeration tons per day to operate "one of the largest capacity [air separation] plants in Japan," producing liquid oxygen (LOX), liquid nitrogen (LN_2) and liquid argon (LA).

LA is in such demand for stainless steel manufacturing that a world-wide shortage exists.[48] LN_2 is used as a refrigerant and in food freezing. LOX has many small quantity uses as well as some large ones, such as solid waste disposal and sewage treatment processes, and paper-bleaching, all of which presently are limited in scope by the cost of LOX. An air separation facility is thus an attractive possibility.

An additional spinoff resulting from LNG cold energy applications is that it could affect an increase in deepwater shipping activity, in the areas of fish product and industrial gas export. Fishing vessel traffic would very likely increase as well. Expansion of shipping

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46 Interview with Edward Rowan, Northwest Natural Gas Company, LNG Project Manager, August 14, 1975.

47 H. Kataoka, "Use the Cold in LNG," Hydrocarbon Processing, November, 1974, V. 53.

48 Interview with Ken Hilderbrand, OSU Marine Advisory Program Director, July 14, 1975.

traffic out of Newport might have the effect of stimulating other development, such as fruit and vegetable export (fresh frozen at Newport), grass seed export, and improvement of transportation linkages, such as a railroad extension from Toledo to Newport. While these possibilities are only speculation at this time, their potential exists and would be increased by the location of the LNG terminal at Newport.

Economic Input-Output Analysis[49]

From the variety of potential economic impacts the LNG project may induce, either directly or indirectly, it would seem that the project could have a large impact on the Yaquina Bay area. To attempt to get a quantitative feel for such potential impacts, the Yaquina Bay area input-output model[50] was used to partially assess project impact.

The input-output method is useful because it takes into account intersector transfers of money coming into the economy from outside sources. Several examples illustrate this process as it applies to the LNG project. First, the employees of the LNG plant, the crew of the LNG ship, and the employees of any induced development will all receive wages, part of which will be respent in the local economy. Businessmen who supply these new residents with goods and services, and those businessmen who supply goods and services directly to the new industries

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[49] The analysis accomplished in this section is crude at best. In use of the 12 year-old Yaquina Bay area input-output model, no attempt was made to update the interindustry transactions matrix. Several other shortcomings are noted in the text regarding the amount and distribution of changes related to the three LNG development scenarios chosen. This present analysis still has some relevance and the author would argue that the aggregate impacts determined are not a bad first approximation.

[50] For background on input-output model development, see Herbert H. Stoevener, et. al. Multidisciplinary Study of Water Quality Relationships: A Case Study of Yaquina Bay, Oregon, Special Report 348, Oregon State University, Agricultural Experiment Station, February 1972.

(such as consumables, ship provisions, etc) will benefit from these expenditures. Moreover, a portion of the increase in the incomes of these businesses is spent again locally, permitting another series of benefits to be recorded. If the Yaquina Bay area economy were self-sufficient, and individuals and businesses retained no income as savings, the cycle of beneficial effects would continue indefinitely, and the multiplier[51] would be infinitely large. There are however, "leakages" of a portion of the original income at each turnover, spent for goods imported from outside the local economy. Actual multipliers are commonly between 1.3 and 3.0.

The Input-Output Model

It was indicated above that there are internal linkages in the local economy and that portions of incoming money are recirculated. Empirical relationships exist for these linkages and can be determined through interindustry analysis.

The Yaquina Bay area model was developed in 1963 to evaluate the impact of recreational sports fishing on the local economy. The economy is represented by a matrix of interindustry relationships which reflect the proportion of purchases by each industry (or sector) from other industries. Table 7 is the original transactions matrix, which essentially is an accounting system of the local economy. Such a model is not useful to analyse the impact of a project in 1975 unless it can be updated with reliable information. This was attempted by the author using several sources of data including employment, sales and other information. From these data, estimates in the % change of each sector

[51] The multiplier is the original dollar purchase and that part of the dollar that remains within the local economy on various turnovers it undergoes. For example if $100 comes into the economy from an outside source, a multiplier of 1.4 says that the total economic impact on local income will be $140, including the original $100.

TABLE 7.

Transactions Matrix, Yaquina Bay Area, Oregon, 1963 (Thousands of Dollars)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Final Demand	Total Sales
1. Lumber, Pulp & Paper..	1,042										400					281	46,887	48,609
2. All Other Manufacturing..................	3		1	15	2	2		2	1	1	54	32			5	15	160	294
3. Hotels, Motels, Trailer Parks.........						1					75				3	244	643	966
4. Cafes & Taverns.......	11			2		1	*									1,112	859	1,985
5. Marinas & Marine Supplies..............	6					64		4			4				*	57	573	708
6. Fisheries.............						358						300					3,991	4,649
7. Service Stations, Automotive Sales & Repair................	2,002		*	2	48	78	1,043	708	68	1	214	52	40	90	76	5,353	1,776	11,552
8. Communications, Transportation............	1,721		19	38	68		24	21	19	38	40	38	5		35	725	192	2,981
9. Professional Services.	22	1	1	1	20	8	1		31	7	3	20	4	4	24	787	216	1,196
10. Banks & Loan Agencies.	60	6	24	24		60	12				6	30	18		3	1,250	116	1,658
11. Construction..........	1,001		41	3	9	6	4	1	4	2	1,354	51	45	5	39	1,487	2,356	6,406
12. Other Product-Oriented Wholesale & Retail....	256	1	170	358	17	356	18	4	27	9	94	135	35	21	62	7,066	1,363	9,990
13. Other Service-Oriented Wholesale & Retail....	43		273	70	14	24	107	22	34	33	120	118	70	7	138	1,941	692	3,706
14. Agriculture...........	70	39										220		3		34	141	507
15. Government............	675	2	21	3	2	10	25	13	5	29	22	47	31	16		596	2,556	4,052
16. Households............	6,983	117	319	571	169	949	1,066	793	595	430	1,349	1,234	2,041	33	2,167	126	5,868	24,808
Import & Value Added..	34,717	128	97	899	359	2,732	9,252	1,413	412	1,108	2,672	7,714	1,417	329	1,500	3,734		
Total Purchases.......	48,609	294	966	1,985	708	4,649	11,552	2,981	1,196	1,658	6,406	9,990	3,706	507	4,052	24,808		124,069

* Less than five hundred.

Source: H.H. Stoevener, et. al., Multi-Disciplinary Study of Water Quality Relationships: A Case Study of Yaquina Bay, Oregon, February, 1972.

were calculated. That these operations are fairly accurate is the first important assumption in the use of the model to evaluate the LNG project. Some examples of why the "updating" of the export final demand values (column 17 in Table 7) is necessary are discussed below.

Both inflation and unequal sector growth rates have occurred in the Yaquina Bay area since 1963, as they have elsewhere. Cumulative national inflation rate has been 58.7%,[52] the Lincoln County travel industry has grown markedly and the forest products industry has declined by at least 25%. In addition, the OSU Marine Science Center has grown to become a major area employer. Such changes have had a significant impact on the local economy and can be estimated. Impossible to determine from existing data, however, are the interindustry relationships which reflect the internal structure of the economy. Herein lies another major assumption with the present analysis; that the interindustry transfers of goods and services occur in the same proportions today as in 1963. This assumption, however, probably has less influence on total impact than on the distribution of these impacts.

An important feature of the original model which is necessarily retained for this application is that the household sector's place in the economy is just like any other business sector. Sales to households in the local area are portrayed as part of the local economy's interdependent structure. Households in turn "sell" their labor for wages, some of which are spent locally, creating a "multiplier" for household income. This is important in model application to the LNG project since much of the increase due to direct and induced industries are inserted through household sector in the form of new wages.

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[52] The inflation rate used was derived from GNP price deflators from 1975 to 1963 as published in Economic Report to the President, transmitted to U.S. Congress, February, 1975 (Table C-3, p. 252).

Input-Output Model Adjustments

The first step in adjusting the 1963 model to reflect 1975 conditions was to inflate each sector's final demand value (which reflects imported money for goods and labor) by 58.7%. Following this, each major sector of the Lincoln County economy was analyzed for possible real growth changes between 1963 and 1975. It was assumed that Lincoln County growth approximates that of the smaller Yaquina Bay area (Newport-Toledo), for which no specific data exists. There is likewise no summarizing data by sector for Lincoln County, so employment figures were used as the most suitable substitute for growth or decline determination. Several sources including the Oregon Department of Economic Development, were queried for information. Most information came from the Oregon Coastal Conservation and Development Commission special economic study team report, "Economic Survey and Analysis of the Oregon Coastal Zone."[53]

From 1963 to 1973, employment in forest products (which includes all industries related to wood and wood fiber) in Lincoln County dropped 47% from 1528 to 809 workers.[54] The increases in pulp and paper industries were not nearly enough to offset heavy losses in lumber and forestry operations. Based on this, a 25% decline in the forest products industry final demand was entered into the model. This may be a bit high since the major forest products employer in the Yaquina Bay area is the Georgia-Pacific Paper mill.

The recreation industry has boomed in Lincoln County, showing a 228% increase, from 368 to 1207 workers between 1963 and 1973.[55] Yaquina Bay is a major center for the travel industry in Lincoln County,

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[53] G. Anthony Kuhn, et. al., Economic Analysis and Profile of the Oregon Coastal Zone, Oregon Coastal Conservation and Development Commission, November, 1974.

[54] Ibid., Table E-11.

[55] Ibid., Table F-22.

with the OSU Marine Science Center public service wing, over 800 small boat moorages,[56] a colorful waterfront, and numerous other attractions. Based on this information, a conservative 100% increase in travel industry final demand figures was assumed, effecting three sectors, 1) hotels, motels and trailer parks, 2) cafes and taverns and 3) marinas and marine supplies.

Lincoln County fisheries, which are almost exclusively based in the Yaquina Bay area, have also grown since 1963. Fish processing employment grew from 129 to 199 between 1963 and 1973, an increase of 54%.[57] Fish landings from 1966 to 1973 were up over 30%, and the value of this catch over the same period is up almost 200%, from $2,080,000 to $6,038,000.[58] Real growth in the fishing industry was thus estimated to be about 50%.

Agricultural employment in Lincoln County dropped by nearly 40%, from 330 in 1963 to 200 in 1973[59]. Real output in the combined areas of crops, dairy products and cattle and calves sold dropped by only 3%, with a large drop in crops offset by increases in dairy and cattle.[60] A decrease of 30% in final demand for agricultural products was introduced into the model.

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[56] Port of Newport, Personal Communication, September, 1975.

[57] Kuhn, Table D-5.

[58] Ibid., Table D-10.

[59] Ibid., Graph C-10.

[60] Ibid., Tables C-15, C-18, C-22.

The OSU Marine Science Center, constructed in 1965, employs about 100 local people and has an annual payroll of $1 million.[61] The households sector was thus directly increased by $1 million to reflect this new source of wages income to the local economy.

No doubt a more thorough analysis of the economy of the Yaquina Bay area could yield more complete estimates of growth or decline in these as well as other economic sectors in the model. These changes, which are summarized in Table 8, are probably a fair approximation of the present final demand (exports) and no doubt better than a mere extrapolation of the old values.

Using the adjusted final demand values, the model generated total output data as shown in Table 8. The adjusted final demand values were also used as the basis of the 1975 economy over which the LNG project could be superimposed. All values used and generated by the model are in 1975 dollars.

LNG Project Impact

A subjective analysis of the LNG project economic impacts was presented earlier. This information is translated here into three potential development scenarios from which new final demand values for certain sectors were estimated. Additional scenarios could have been developed, but difficulty in estimating the changes in various sectors contributed to selection of the three chosen.

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[61] David Zoff, OSU School of Oceanography, Personal Communication, September, 1975.

Table 8. Adjustments of Yaquina Bay Input-Output Model to More Closely Reflect the 1975 Economy (dollars in thousands)

	Sector	1963 Final Demand		1975 Inflated Final Demand	Sector Adjustments*	1975 Adjusted Final Demand**	1975 Adjusted Total Output** (model generated)
1.	Lumber, Pulp & Paper	46,887		74,410	25% decrease	55,807	58,093
2.	All Other Manufacturing	160		254	N.C.	254	477
3.	Hotel, Motel, & Trailer Pr.	643		1,020	100% increase	2,040	2,540
4.	Cafes & Taverns	859		1,363	100% increase	2,726	4,474
5.	Marinas/Marine Supply	573		909	100% increase	1,818	2,074
6.	Fisheries	3,991		6,334	50% increase	9,501	10,821
7.	SVC. Sta., Auto RPR, Sales	1,776	58.7%*	2,818	N.C.	2,818	17,209
8.	Communications/Transportation	192	Inflation	304	N.C.	304	4,154
9.	Professional Services	216	1963-1975	342	N.C.	342	1,822
10.	Banks & Loan Agencies	116		184	N.C.	184	2,568
11.	Construction	2,356		3,739	N.C.	3,739	9,672
12.	Other Product-Oriented Wholesale & Retail	1,363		2,163	N.C.	2,163	16,199
13.	Other Service-Oriented Wholesale & Retail	692		1.098	N.C.	1,098	5,481
14.	Agriculture	141		223	30% decrease	156	717
15.	Government	2,556		4,056	N.C.	4,056	6,167
16.	Households	5,868		9,313	$1 million increase	10,313	38,536

* Inflation Figure used and sector adjustment rationale explained in text.

** Adjusted values were the economic base upon which the LNG project scenarios were superimposed.

N.C. - No change.

The economic impact of each development scenario was determined by increasing the final demand in each effected sector (most sectors had no change) by some absolute increase as illustrated in columns 3, 5 and 7 of Table 9. These changes in final demand were injected into the input-output model, generating new total output data for each sector. Simple economic multipliers were then calculated for each development scenario by dividing the change in total output by the change in final demand which was inserted into the model. A summary of each development scenario is presented below.

Development Scenario 1: LNG Import Terminal with no induced development

Sector	Change	Increase in Sector Final Demand (absolute and % increase)
Households	10 LNG plant workers at average wage of $12K/yr	$120,000
	20-man ship crew which resides in Newport at average wage of $15K/yr.	$300,000
	Increased Bar Pilot Income	$ 20,000
	Total	$440,000 (4.27%)
Other Product-Oriented Wholesale & Retail	Ship Provisions	$ 60,000
	Total	$ 60,000 (2.77%)

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Development Scenario 2: LNG Import Terminal with Ice and Cold Storage Plant and Increased Fish Landings

Sector	Change		Increase in Sector Final Demand (absolute and % increase)
Households	LNG plant/ship crew/ Bar pilot wages income (same as Scenario 1)		$440,000 (4.27%)
	Ice/Cold Storage Plant 20 workers at average wage of $12K/yr.		$240,000
		Total	$680,000 (6.41%)
Other Product-oriented Wholesale & Retail	Ship Provisions		$ 60,000
		Total	$ 60,000 (2.77%)
Fishing	25% increase in Fish landed due to additional facilities to provide ice and cold storage for non-local processors. (25% x $9,501,000)		$2,375,000
		Total	$2,375,000 (25%)

Development Scenario 3: LNG Import Terminal with ice and cold storage, increased fish landings and a new major fish processor (canning and freezing).

Sector	Change		Increase in Sector Final Demand
Household	LNG plant/ship/bar pilot		$440,000
	Ice/cold plant		$240,000
	major fish processor with 200 employees at average of $10K/yr.		$2,000,000
		Total	$2,680,000 (26%)
Fishing	25% increased landings (same as Scenario 2)		$2,375,000
		Total	$2,375,000 (25%)
Products	Ship Provisions		$ 60,000
	Fish processor supplies (consumables, etc., based on existing data on intersector spending)		$ 765,000
		Total	$ 825,000 (38.1%)

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Two major problems result by virtue of the estimates used to predict economic changes associated with each development scenario. First, most of the increases have been entered through the household sector, representing new sales of labor which result in income. Due to the short time period in which this analysis took place, not all inter-industry purchases between sectors were included. For example, purchases of goods and services such as consumables, water, etc. by the LNG plant was not included since it was not known. A second major problem is that all of the new household income was assumed to have been spent locally, with no leakages to taxes, savings and direct outside purchases. Further analysis now in progress will attempt to correct this error, though this and the previous discrepancy noted should tend to counterbalance one another.

The economic impact of each of the development scenarios is presented in Table 9. Total output increased in each case as expected, with 0.66% increase for Scenario 1, 3.46% for Scenario 2, and 6.89% for Scenario 3. Simple income multipliers for the three scenarios were 2.24, 2.01, and 2.12 respectively.

As a result of scenario 3, for example, these multipliers say that for each new dollar entering the local economy, there will be an additional $1.12 of respending within the local economy. The multiplier is determined as a ratio of the change in total output divided by the change in export final demand. This would seem to imply that Scenario 1 will result in the greatest economic impact. Since its multiplier is highest. This is not true, however, because the total number of dollars in new business sales also plays a very important role in evaluating total economic impact.

Table 9. Economic Impact of LNG Project Under Three Development Scenarios Using Yaquina Bay Area Input-Output Model (Dollars in Thousands)

Sector	1975 Adjusted Final Demand (1)	1975 Adjusted Total Output (2)	IMPACT SCENARIO 1 New Final Demand (3)	New Total Output (4)	Absolute CHG. in T.O. (4-2)	% Δ in T.O. $(\frac{4-2}{2} \times 100)$	IMPACT SCENARIO 2 New Final Demand (5)	New T.O. (6)	Absolute Δ in T.O. (6-2)	% Δ in T.O. $\frac{(6-2)}{2}$	IMPACT SCENARIO 3 New Final Demand (7)	New Total Output (8)	Absolute Δ in T.O. (8-2)	% CHG. in T.O. $\frac{(8-2)}{2}$
1. Lumber, Pulp & Paper	55,807	58,093	N.C.	58,102	9	0.02%	N.C.	58,120	27	0.05%	N.C.	58,166	73	0.13%
2. All other Manufacturing	254	478	N.C.	479	1	0.21%	N.C.	484	5	1.05%	N.C.	495	17	3.56%
3. Hotel, Motel, & Trailer Pk.	2,040	2,540	N.C.	2,547	7	0.28%	N.C.	2,559	12	0.47%	N.C.	2,588	48	1.89%
4. Cafes and Taverns	2,726	4,474	N.C.	4,500	26	0.58%	N.C.	4,548	74	1.65%	N.C.	4,669	195	4.36%
5. Marinas/ Marine Supply	1,818	2,074	N.C.	2,076	2	0.10%	N.C.	2,114	40	1.93%	N.C.	2,121	47	2.27%
6. Fisheries	9,501	10,821	N.C.	10,828	7	0.06%	(+2,375)25% 11,876	13,419	2,598	24.01%	(+2375)25% 11,876	13,471	2,650	24.49%
7. Svc. Sta., Auto Rpr, Sales	2,818	17,209	N.C.	17,357	148	0.86%	N.C.	17,686	477	2.77%	N.C.	18,390	1,181	6.86%
8. Commun/Trans	304	4,154	N.C.	4,175	21	0.51%	N.C.	4,218	64	1.54%	N.C.	4,317	163	3.92%
9. Prof Ser.	342	1,822	N.C.	1,841	19	1.04%	N.C.	1,884	62	3.40%	N.C.	1,977	155	8.51%
10. Banks & Loan Agencies	184	2,568	N.C.	2,598	30	1.17%	N.C.	2,689	121	4.71%	N.C.	2,834	266	10.36%
11. Construction	3,739	9,672	N.C.	9,719	47	0.49%	N.C.	9,812	140	1.45%	N.C.	10,036	364	3.76%
12. Other Product-Oriented Wholesale & Retail	2,163	16,199	(+60)2.77% 2,223	16,434	235	1.45%	(+60)2.77% 2,223	16,960	761	4.70%	(+825)38.1% 2,988	18,557	2,358	14.56%
13. Other Service-Oriented Wholesale & Retail	1,098	5,481	N.C.	5,534	53	0.97%	N.C.	5,652	171	3.12%	N.C.	5,912	431	7.86%
14. Agriculture	156	717	N.C.	723	6	0.84%	N.C.	737	20	2.79%	N.C.	777	60	8.37%
15. Government	4,056	6,167	N.C.	6,184	17	0.28%	N.C.	6,222	55	0.89%	N.C.	6,305	138	2.24%
16. Households	10,313	38,536	(+440)4.27% 10,753	39,107	571	1.48%	(+680)6.41% 10,993	40,170	1,634	4.24%	(+2680)26% 12,993	42,861	4,325	11.22%
TOTALS	97,319	181,005	(500)0.51% 97,819	182,204	1,119	0.66%	(3115)3.2% 100,434	187,274	6,269	3.46%	(5880)6.04% 103,199	193,476	12,471	6.89%
			Multiplier = $\frac{1119}{500}$ = 2.24				Multiplier = $\frac{6269}{3115}$ = 2.0				Multiplier = $\frac{12471}{5880}$ = 2.12			

NOTE: Figures in parentheses and percentages are absolute and percent increase.

The impact of the LNG Import Terminal on the local economy, without any induced development (Scenario 1), will be almost imperceptible, with little more than a $1 million increase in total output. The addition of an ice/cold storage plant and increased fish landings (Scenario 2) pushes total output up by more than $6 million. The location of a major fish processor in the area (Scenario 3), has the greatest economic impact, showing increased total output of almost $12.5 million. While these results are intuitively what one would expect, the input-output analysis helps focus on the magnitude of the impact of each scenario and its distribution. In general, the sectors most effected were those in which increases in final demand were injected (households, fisheries, other product-oriented wholesale and retail). Other sectors which noted a significant relative increase were service stations/auto repair/sales, professional services, banks and loan agencies, other service-oriented wholesale and retail, and agriculture. The maximum benefits to the local economy (in terms of new jobs and money) result when full utilization of the LNG cold energy is made.

Another scenario of development which was not evaluated would involve the location of an air separation plant in the area, which could use LNG cold energy to manufacture liquid nitrogen, oxygen and argon. Development of new final demand values for this scenario would have required a more detailed description of its potential spending patterns than was available.

Whatever the pattern of eventual LNG-related development, some of the benefits of the type described here may be negated by adverse impacts in other sectors. Some of these, particularly those related to resource commitment and degradation, may not be immediately discernible in economic terms, but should be considered by those responsible for decision-making at the local, state and federal level. Some of these potential costs are discussed in the next section on environmental impacts.

SECTION 3

REVIEW OF ENVIRONMENTAL ASSESSMENTS

Environmental Assessments Accomplished

The Yaquina Bay LNG project has been the subject of significant environmental analysis and review by many local, state and federal agencies. While most of the direct environmental concerns involved with construction and operation of the LNG facility were dealt with, many of the more subtle, and in some cases, more important impacts were overlooked or inadequately treated. That this could occur becomes understandable when the fragmented structure of the present environmental management regime is analyzed, as is done in the next section of this report. This current section, however, is concerned more with identification of these overlooked or inadequately treated environmental impacts. While these impacts may not have prevented or changed the course of the project, they give one a more complete perspective of the possible effects on the Yaquina Bay area.

Three efforts to date have been important in assessing the environmental effects of the Newport LNG project. The most comprehensive work, "Siting Consequences of the Newport LNG Receiving Terminal",[62] was prepared by Northwest Natural Gas in a format similar to a federal environmental impact statement with some additional items of local significance. This report was requested by the Yaquina Bay Task Force, a citizen's advisory group to the Lincoln County Planning Commission for matters relating to estuary waterfront land use. While this report spelled out many of the environmental effects in an excellent manner, potential water quality impacts were overlooked, safety hazards somewhat understated, and possible induced or secondary effects not included.

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[62] Northwest Natural Gas Company, "Siting Consequences . . ."

A second environmental report was prepared for the Governor of Oregon by his Advisory Committee on Environmental Science and Technology.[63] This report was limited in scope to an evaluation of the hazards of LNG transport and storage in relation to this project. These hazards were accurately and concisely presented.

The widest exposure of the project to state and federal agencies came as a result of Northwest Natural's permit application to the U.S. Army Corps of Engineers/Oregon Division of State Lands, for the dredging of the LNG tanker berth. This interagency review, however, concerned only this one small aspect of the project, though input by the federal Environmental Protection Agency, Oregon State Fish Commission, and others led to a minimizing of the dredging impacts. Upon completion of the review, the Corps of Engineers concluded that ". . . no environmental impact statement (EIS) for the proposed permit is required."[64] With dredging accomplished and site construction underway, it is not expected that a federal EIS will be required for the project. This may not be the case, however, if the LNG facility comes under closer scrutiny when permit application for wharf construction is made. Likewise, if a new LNG supply is obtained or the original contract, which has been dissolved, is renegotiated, subsequent certification by the Federal Power Commission may require the preparation of an EIS.

Additional portions of this section describe some additional environmental impacts that might be expected from this project, as well as gaps in present knowledge which would be necessary to adequately assess impacts. Some of these impacts are speculative in nature and their

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63 Advisory Committee on Environmental Science and Technology [Governor of Oregon], Evaluation of LNG Transport and Storage Hazards, March 14, 1974.

64 U.S. Army, Corps of Engineers, Portland District, Environmental Evaluation and Finding For Permit Application No. 071-OYA-1-001355, March 27, 1974.

inclusion does not imply that they are inevitable, but only that they are possible. The author believes that all such potential impacts should necessarily be identified as they may contribute to better planning and management of available resources in the future.

Water Quality Impact

Each of the three impact assessment efforts cited above deal with water quality to one degree or another. The dredging permit review concerned itself only with impacts associated with that operation. The dredging has been completed (May, 1974) and the banks adjacent to mudflats and water rip-rapped to prevent erosion. This is cited by Northwest Natural as affecting an improvement in water quality since substantial bank erosion has been alleviated.

LNG itself is characterized as a non-polluting substance that does not impair water quality. This is due to its high volatility at ordinary temperatures and its low density compared to water (see Table 1). In a listing of hazardous materials by the Environmental Protection Agency, methane (the primary LNG component) was characterized as non-persistent, with no human, fish, plant or rat toxicity.[65] A search of literature, however, showed no research into any of these potential effects. The physical nature of LNG is such that research into possible polluting effects is not deemed necessary. This is supported by communication with researchers dealing with LNG technology.[66]

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65 U.S. Department of Interior, Federal Water Quality Administration, Control and Spillage of Hazardous Polluting Substances, November 1, 1970, Table B-1, p. B-27.

66 Dr. Robert C. Reid, LNG Research Center, MIT, Personal Communication, 31 July, 1975.

The author speculates that there would be a short term impact if a major water spill of LNG occurred, but with no persistent effects. Spilled LNG would vaporize rapidly, immediately lowering the temperature of the water, with subsequent ice formation at the LNG-water interface. After dispersal of the vapor cloud, the ice would quickly melt. Localized mortality due to cold shock might be expected, either in the water column or on tideland fringes, should the spill carry that distance.

Most LNG contains 0-30% impurities, including varying amounts of ethane, propane, butane, pentane, and hexane as well as some inorganic nitrogen, sulfur, and other lesser constituents. Cetain of these impurities are more persistent than methane and can have toxic effects on fish and wildlife.[67] Impurities are thus a water quality consideration if their concentrations in the LNG are sufficient. If Northwest Natural gets gas from Alaska similar to that it originally contracted for, its extremely high methane content (99.6%) will negate any such "impurities problem."

The possible effect of a fuel oil spill has far greater potential impact on the physiochemical properties of estuarine waters than an LNG spill. Northwest Natural is hopeful that refueling can be accomplished wherever the LNG is obtained. In the event that this is not possible, the necessary storage tanks and refueling equipment will need to be installed at the Newport facility. Such a development would substantially increase the potential for oil spills in the bay. Fuel oil could also be spilled in the unlikely event of a ship grounding or collision. A combined LNG/fuel oil spill cannot be ruled out in such an instance.

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[67] Federal Water Quality Control Administration, Control and Spillage . . . , Table B-1.

Expected physical and water quality effects associated with a fuel oil spill have been substantially researched, but are still not well known. Primary production and dissolved oxygen levels will decrease, due to reduction of light into surface waters. Marine organisms will incorporate dissolved hydrocarbons into food webs, with both lethal and non-lethal toxic effects. More obvious is the coating of benthic organisms and waterfowl. Petroleum products seem to be quite persistent in some cases, concentrating in sediments as well as organisms. Microbes that decompose petroleum products in marine waters have such high oxygen requirements that the resulting oxygen depletion can cause deleterious effects to other organisms. Even small spills in an estuary the size of Yaquina Bay could have serious impact.

Small discharges of materials incidential to construction and maintenance operations, such as paint, solvents, lubricating oils, and natural gas odorizer (methyl mercaptan) will undoubtedly occur. Because of the very small quantities used and the infrequency of the spills, such incidents in and of themselves are not expected to significantly effect the quality of estuarine waters. However, such incremental addition of pollutants does have a cumulative effect that can cause significant environmental deterioration over time.

Cooling water disposal may or may not be a problem. In all likelihood, Northwest Natural will dispose of its mechanical equipment cooling water in the Newport sanitary sewage system. The Linnton LNG plant in Portland uses up to 100,000 gallons per day of cooling water for its mechanical equipment, discharging the heated effluent (90°F-100°F) into the Willamette River.[68] The Newport LNG facility will require 144,000 gallons of water per day,[69] most of which will be used for mechanical equipment cooling, if the Linnton plant can serve as a guide. In the

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[68] Glen Carter, Oregon Department of Environmental Quality, Personal Communication, August, 1975.

[69] Northwest Natural Gas Company, "Siting Consequences . . ," p. 25.

event that estuary disposal is opted for, the 144,000 gallons per day equates to a constant discharge rate of 0.16 cubic feet per second. This will probably cause a localized alteration in the natural system. It might be expected that the warmer water would attract certain fish and other organisms. Sewage waste could be disposed of through a sanitary sewer hookup or by on-site treatment, but in no case should the effluent be disposed of in the estuary.

It is estimated by the author that annual maintenance dredging in lower Yaquina Bay will increase by 4-6% as a result of the LNG project (20,000-30,000 cubic yards).[70] In order to keep the port open on a year-round basis for the deep draft LNG ship, more frequent dredging may be required, particularly at the harbor entrance, where winter shoaling is most significant. Any increase in dredging will result in similar incremental increase in the negative impacts associated with that operation. This includes increased turbidity, modification of salt water intrusion patterns, modification of current patterns, displacement and mortality of organisms, and potentially increased toxicity if any of the material to be dredged is polluted (it was earlier shown that sediments are polluted at several lower Yaquina Bay sites). There will also be proportionately increased negative effects on the offshore ocean dump sites.

In summary, the impact of LNG facility operation on water quality during normal operations will probably be minimal. The impact of a large spill of LNG on water is expected to be negligible, but no substantiating research has been directed toward this question. By far the greatest impact the LNG project will have on water quality will be through other more indirect routes. As a result of the free energy resource offered by the LNG cold, other sectors of the local economy,

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[70] This estimate was based on increase in bottom surface area of dredging project as depicted on the chart of Yaquina Bay and River, C & GS 6055.

such as fishing, fish processing, manufacturing and others, could expand. These secondary impacts have not been discussed in previous reports on the LNG project, except from the benefits aspect associated with economic growth. Such analysis is usually an integral part of a comprehensive impact study, which, as previously noted, was not produced for this project.

Land and Air Quality Impacts

Northwest Natural indentified the primary impacts of the LNG project on land use in their "Siting Consequences" report. Major among these is that the twenty-one acre site on which the facility is being constructed is committed for the life of the project. Another major indirect land impact is that the surrounding land may be more quickly industrialized if LNG cold energy utilization schemes materialize.

An unidentified impact, again of an indirect nature, involves the adjacent Sally's Bend area. About 25% of this mudflat area adjacent to the existing LNG site landfill is zoned for Marine Industrial use (see Figure 14C). This implies that future plans may call for the filling of this area, which amounts to more than a hundred acres. While there would be opposition to such a proposal on some fronts, a speedup of industrialization could bring about significant pressure to fill the area in accordance with the established Bay plan. One could imagine that the distant future may see the entire Sally's Bend area committed to industrial use. This was apparently among the long-range plans for the port prior to awakening of environmental interests. While this would appear unacceptable from an environmental perspective, such a trade-off may have to be made if other estuarine areas are to be preserved. Future "10-year plans" which follow the present marine development plan will inevitably involve further development, though the existing policies of the Yaquina Bay Task Force would seem to imply some developmental ceiling exists. The real challenge is to maintain environmental quality while providing for the multiple economic uses of the estuarine resources.

Air quality degradation associated with the LNG project will be minimal. Clean-burning natural gas will be used to fuel the vaporizers and heat buildings, and the increased ship traffic will add some air pollutants, but the consistent ocean breeze will prevent any noticable air quality degradation. An air pollutant emission permit has been obtained by Northwest Natural for plant operation from the Oregon Department of Environmental Quality.

Hazard and Health Impacts

The nature of LNG was discussed in Section 1 of this report, and should be referred to for a more detailed analysis of the hazards associated with LNG. The primary hazards are reiterated below.

The foremost hazard associated with the Newport LNG facility will result only if there is a spill of LNG. The dense vapor cloud formed by the rapidly evaporating liquid is flammable within certain limits of gas-air mixture. Depending on a number of environmental variables, and the amount and rate of spill, such a flammable cloud may drift anywhere from several hundred feet to a mile or more downwind (refer to Table 3 and 4).

Should a confined spill of LNG (i.e. within the diked area around the tank) ignite, the resulting fire would pose a severe radiant heat problem. Windy conditions would further extend radiant heat effects in the downwind area. A spill of LNG on water with subsequent ignition of the vapor cloud would pose an even more serious problem due to unconfined spreading and more vigorous vaporization. In either event, adjacent facilities, both existing and future, could be in danger in the event of an LNG spill and fire.

There is a popular but INCORRECT notion that LNG will explode on contact with water, and that the vapor cloud will explode when it ignited. Such fears are based on erroneous information since, as noted earlier, LNG has a high ignition temperature and once ignited, a low flame velocity. In fact, difficulty often has been encountered in purposely attempting to ignite LNG for experimental tests. While fears of catastrophic explosions are unjustified, a large spill and subsequent vapor cloud formation could cause associated fires in the cloud path if conditions were appropriate and an ignition source present.

None of the above hazards are associated with normal LNG plant operation and will only become reality in the unlikely event of a significant spill and fire. While the odds against such an occurrence are high, Northwest Natural and the Newport community must assume that a spill will occur at some time and be prepared to cope with it in an effective manner.

Most natural gas contains radioactive radon (222RN). Much of this is removed during processing, but some remains in LNG when liquified. When burned, natural gas releases this radioactivity to the atmosphere. This radiation can be a significant source of exposure within buildings where unvented gas is burned and is considered a potential health hazard.[71] This should not be a problem for the LNG facility, but is noted primarily for purposes of discounting any impact which might otherwise be construed.

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[71] T.F. Gessel and H.M. Prichard, "The Technologically Enhanced Natural Radiation Environment," Health Physics, April, 1975, V. 28, p. 363.

Visual/Amenity Impacts

The LNG project will be a major addition to marine-related heavy industry in Yaquina Bay. It will cause a slight shift in the character of the bay toward the important deep-water port some aspire it to be. Induced development, particularly of a manufacturing nature, may further cause a shift in this direction.

It is difficult to evaluate amenity and visual impacts of development due to different individual tastes and value systems. There are a myriad of factors which will enter into each individual's perception of the LNG facility. For some, the 125 foot high tank will be an obtrusion into an otherwise natural environment. To others, the facility will be viewed as a sign of progress and economic growth, and therefore be attractive. Whatever the perspective of the viewer, the LNG facility will alter the character of the bay, block otherwise scenic views of some north shore residents and generally be visable from most bay and shoreline vantage points. Compared to the rest of the bay, the area will have a somewhat stark, sterile appearance. Due to the fire hazard associated with any potential LNG spill, it is doubtful that a natural-appearing landscape can be created as has been accomplished across the bay on the Marine Science Center fill area. Some mitigation of the visual impact of the tank itself could be accomplished by selection of an appropriate color which will blend into the existing backdrop.

The LNG facility itself will probably not have a negative impact on the tourist/boating industry on the bay. If anything, the facility and shipping activity will attract curiosity seekers and visitors who want to experience the flavor of a coastal port. Most residential commericial and marina development is far enough removed from the actual site so as to be minimally effected.

Public Services Impact

Though the LNG project is well underway, there has been no arrangement made as of yet for needed sewage and water service. There has been discussion with the City of Newport about extending services to the project site. This would involve a 3/4 mile extension for sewer over the public right-of-way and would cost about $55 thousand, according to the city engineer's estimate. Water service would require a 1/2 mile extension over private property from the nearby Newport Terminals area, and cost about $50 thousand.[72]

If Newport does extend services to the LNG facility, it is likely that they will annex the site to the city, thereby increasing the city taxbase by more than $10 million (up to $13 million with the peak-shaving plant installation). Based on a city tax rate of $24.31 per thousand of assessed valuation, this would increase tax revenues by at least $243 thousand per year. If the facility remains on the county tax rolls, the $15.98 per thousand tax rate would generate about $160 thousand in annual tax revenues. Therefore, it can be stated that the LNG facility will "pay its own way."

The only other significant public service demand will be fire protection. A unique responsibility will be incurred here, requiring extensive personnel training and possibly new specialized fire-fighting equipment. Other public services, such as schools, hospitals, police, government, etc. will not be heavily impacted by this capital-intensive project.

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[72] Dennis Davison, Lincoln County Planning Department, Personal Communication, September, 1975.

Compatibility With Present and Planned Uses

It was shown in an earlier section that competition for limited coastal resources is great. Conflicts of a spatial, temporal and ecological nature exist and are complicated by interactions and individual perceptions. In this context, how does the LNG import terminal project fit in with existing and planned uses of the estuary?

The LNG import terminal would be compatible and even complementry to several important estuary uses, while potentially incompatible with others. If utilization of the LNG cold resource comes to pass, fishing and fish processing stand to benefit. Other dependent industries may also develop. Contrasting this are some industries which might stand to be negatively effected, including aquaculture and marine recreation. Continued industrialization, induced by the LNG project, may degrade water quality and bay fisheries, reducing the unquantifiable value of the recreational experience and adding water treatment costs to aquaculture operations. These conflicts are only speculative and should not be construed as inevitable. In fact, the LNG facility in one sense adds to the character of Newport as a coastal port and thus may enhance recreation in an indirect way.

One could argue that the location of the LNG project on the Yaquina Bay precludes the use of the project site and adjacent area for other marine industrial activity. This may be so, but with Newport's lack of drawing potential for other marine industry/deep-water shipping, it does not seem to be a valid argument. Furthermore, there are few types of industrial activity possible for Newport that could equal the LNG project in potential beneficial spinoffs.

In summary, the LNG import project has a favorable or neutral impact on most other uses of Yaquina Bay estuary. Such is not the case with the project if LNG is unattainable and the facility is operated as a "peak-shaving" plant. All of the complementarity is lost and the use of the site for an LNG plant becomes non-marine-related. It is also incompatible with Yaquina Bay Task Force development policy and waterfront land use criteria. The only rationale for allowing the LNG project to continue as a peak-shaving plant is that its location there will allow rapid conversion to an import terminal once a supply of LNG is obtained. It is assumed that Northwest Natural is making every effort to do so.

SECTION 4

ENVIRONMENTAL MANAGEMENT REGIME: ANALYSIS AND NEEDS

Analysis

Numerous federal, state and local agencies and groups have been directly or indirectly involved with the Yaquina Bay LNG project. These include the federal U.S. Army Corps of Engineers, the Environmental Protection Agency, the Bureau of Sports Fisheries and Wildlife, the Oregon State Division of Lands, Department of Environmental Quality, State Fire Marshal, Fish and Wildlife Commission, Lincoln County, the City of Newport, the Port of Newport, the Yaquina Bay Task Force, and others. Without detailing the particular concerns of each, an attempt will be made to put the environmental management regime in perspective.

At first glance, it seems that the Yaquina Bay area has a sound program of environmental management. As noted earlier, Yaquina Bay has land and water surface zoning, a marine-oriented development plan and a small, but active task force of concerned citizens to oversee both. This, combined with the expert assistance of state and federal agencies when permits are required would seem to be adequate. However, if the LNG project serves as an example, the system proves to be less effective than anticipated.

During the process of gathering and distilling information about the LNG project, several problems related to environmental management emerged. While they overlapped somewhat, they each retained a distinct identity. These problems included:

1) An inadequate institutional and legal framework within which a comprehensive evaluation of project impacts can be made,

2) A lack of coordination with regard to timing of permit requirements and certifications, and

3) A lack of citizen participation and availability of project information at the local government level, particularly in the project planning stage (prior to approvals).

Some illustrations of each of these problems is provided below. Such illustration using various actions of the gas company or agencies involved should not be construed a determination of fault. More often, it is the institutional system within which they are compelled to operate that is to blame.

The inadequate institutional framework is most easily illustrated. No comprehensive environmental and economic impact study was made. The Corps of Engineers could have chosen to prepare a complete environmental impact statement (EIS) rather than the dredging-only assessment. This would have provided a basis for more informed local decision-making and public involvement. The Corps chose not to do so, and the decision was in their opinion defensible. The problem then becomes one of substituting some other mechanism to allow this necessary information gathering and evaluation to occur. The Yaquina Bay Task Force "requirement" for environmental assessment of major projects has potential usefulness, but it is not legally bound by law.[73] The Task Force is a citizens advisory group with no legislated power. They require no formal review period or

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[73]Yaquina Bay Task Force, Yaquina Bay Marine Development Plan, p. (specific items to be included in the impact assessment are outlined).

public hearing for the assessment and do not possess the special expertise to critically evaluate its quality and accuracy. With the LNG project, this report served mainly as an after-the-fact justification of previously granted permits.

The Yaquina Bay Task Force has the potential to be more than just an advisory body to the planning commission for waterfront land use.[74] Land use decisions within the entire bay area have impact on the estuary as a natural system and fall within the purview of their stated policies and objectives.

The second major problem involves poor timing, which is illustrated by analysis of the permit processes. For example, the Lincoln County Planning Commission approved the LNG project on December 10, 1973, five days after receipt of an initial Northwest Natural Gas impact report, which was deemed inadequate,[75] and seven days before approval by their "waterfront land use advisory body", the Yaquina Bay Task Force. It is notable that the conditions specified by the Task Force "approval," which were not binding, were significantly more complete and meaningful than that adopted a few days earlier by the Planning Commission. It may have been useful for the Planning Commission to wait for the advice of the Task Force. A more complete Northwest Natural Gas impact assessment was not available until April 5, 1974,[76] well after most required permits were obtained. Other examples of poor planning with regard to time

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[74]According to a Lincoln County Planning Department staff member, the task force has little influence on land use decisions on non-waterfront lands.

[75]The author did not review this first report, but its inadequacy is assumed since the Yaquina Bay Task Force requested a more complete assessment be made in their designated format.

[76]Northwest Natural Gas Company, Siting Consequences of the Newport LNG Facility.

involve the provision public services for the site. Arrangements for water and sewage still have yet to be made, though construction of the facility is well underway. Corps of Engineer permits for wharf and fire pump construction also are still outstanding, but their approval is probably a foregone conclusion at this stage of the project. However, what if the Corps now decides that an EIS is required? Will this add delay to the whole project? Will the Federal Power Commission (FPC) require an after-the-fact EIS, when certification of the facility is made for LNG importation? Timing and coordination of permit requirements prior to project committment would go far toward enabling local government and public to evaluate the total impact of a project on their community. Economic benefits attributed to a project should not be used as lubrication for the bureaucratic process, particularly when they are conditional or questionable. This may be easy to say, but when new economic opportunities are few and woes many, it is understandably difficult to practice.

The lack of citizen participation and adequate information about the project and its impacts has been implicit in the above discussion. An additional and more fundamental problem is the inadequacy of the information base for the project area, Yaquina Bay. The most recent collection of information for management purposes was in 1969.[77] More recently, the publication, Oregon's Estuaries,[78] provided a summary and listing of source materials, but this was found to be incomplete and not

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[77]Bureau of Governmental Research and Service, Preliminary Land Use Plan for the Yaquina Bay Area, September, 1969.

[78]Katherine L. Percy, et. al., Descriptions and Information Sources for Oregon's Estuaries, Sea Grant College Program, Oregon State University, May, 1974.

really usable for developing planning and management implications. A system is needed to monitor new social, economic and environmental information and translate it into improved management and environmentally sound development.

Estuary Management Needs

Review of the LNG project and the associated environmental management regime reveals some basic inadequacies. There are probably several ways to strengthen the management system, particularly through increased state and federal involvement. Such a "solution", however, is rejected because as shown by the earlier Yaquina Bay experience, estuary planning and management is most successful when directed at the local level. Specialists are needed to provide information, highlight the options and point up various pitfalls. Local people should be the decision-makers except in clear areas of state or federal interest. What are some options for improving the process of estuary management? Several possibilities are offered below.

The first proposal would be to establish a comprehensive impact assessment process, to serve as a link between individual project and regional (i.e. entire estuary) plans. Integral to such a process would be local participation. It also would be necessary that the assessment take place prior to construction commitment and permit granting, that it be based on well-defined impact assessment criteria, that expert review be provided for, and that it be relatively simple and fast.

Some of these requirements for an impact assessment process seem contradictory, but such a framework is presently being developed and soon to be demonstrated by the Oregon State University Extension Service.[79]

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[79] This project, entitled "Environmental Impact Assessment: A Framework for Local Participation and Decision Making" is being directed by OSU Extension Service Land Resource Specialist, James R. Pease. Project Manager and environmental specialist is Richard C. Smardon.

It is not designed as "just another requirement", but rather as a facilitator of sound project planning. It could be adopted as the tool through which the planning commission and staff evaluate the impacts of a project and its place in the larger regional scheme. The framework is being designed for implementation in three phases, each more complete than the former. Extension Service assistance would no doubt be provided.

Another valuable addition to Yaquina Bay estuary management would be a resource information system. Such a system would consist of several elements, each serving different needs. Some of these might include:

1) a continuously updated economic and environmental data base of resource and research information in format useful for management,

2) an information display element, consisting of graphic and visual displays of information such as system models, aerial photography, maps, etc.,

3) a public information element, to provide educational materials about the estuarine system and various development proposals, and

4) a needs-identification element, designed to identify gaps in knowledge and communicate that information to research organizations for possible action.

Such an information system could be organized in several ways to best suit the needs of the users. The need for continued maintenance is stressed as essential to decision-making and public involvement processes.

A third proposal involves the analysis of various alternative techniques for estuarine management. The application of land use type controls for estuarine areas is a relatively new phenomenon. Using Yaquina Bay's 1969 plan as a model, several other estuaries have been planned and zoned in similar ways. Zoning, however, is fraught with problems as a land use control. Extension of the technique to estuaries will undoubtedly serve to bring along at least some of these problems. In a report to the President, the Council on Environmental Quality summarized the deficiencies of zoning:

> Zoning has certain inherent problems as a land use control. Inasmuch as it can change the price of land from its free market value, zoning may create economic incentives which work against the successful implementation of the desired development patterns . . .
>
> A second problem with zoning derives from its underlying assumption that different uses should be segregated. In terms of convenience, environmental effects, and energy consumption, there are often significant advantages to locating neighborhood facilities such as a grocery store or a pharmacy within a residential area. . .
>
> An even more basic question in zoning is whether it is possible, or even desirable, for a community to establish firm criteria for land use that are expected to remain unchanged over a long period of time. Experience suggests that it is not.[80]

There are numerous other techniques for controlling land use which may in some combination provide for optimum estuary management. A few, such as performance standards, impact zoning and transferrable development rights are briefly discussed.

Performance standards differ from traditional zoning in that they are designed to measure "effects" of a particular project rather than the "use." Traditional zoning restricts certain uses to specific areas

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[80]Council on Environmental Quality, Land Use, reprinted from the Fifth Annual Report of the Council on Environmental Quality, December, 1974, p 52.

whereas with performance standards, theoretically any use is permitted in any location, as long as performance standards are met. Examples of performance standards are the environmental pollution standards which already exist for Yaquina estuary as well as other water bodies. Performance standards also have been developed for traffic generation or attraction potentials of development, for aesthetics, social and economic impacts, and land capacity. These and perhaps other standards based on estuarine characteristics could be applied in the case of Yaquina Bay. For example, in estuarine areas designated for protection, adjacent development with only specified maximums of traffic generation might be allowed.

Impact zoning is a variation of performance standards which implies a balancing of impacts, taking into account social and economic as well as environmental standards. It has been used particularly for planned residential developments, applied over existing base level controls such as zoning. The result has been developments which are fiscally sound as well as more compatible with the environment. Conceptually, a variation of impact zoning for estuarine areas holds interesting possibilities, channeling into areas only those uses which can be supported by the natural, social and economic system.

Transferable development rights is based on the notion that land ownership is really ownership of a "bundle of rights," and that one of these rights is development. A region may set limits of development in an area at 30% of the land surface. Each parcel owner would then be able to develop 30% of his land; if he desired to develop more, and other standards did not impede him, he would be required to purchase the development rights of another owner, who in turn would give up his rights for development. Such a system would ensure that 70% of the land would remain as open space. In conjunction with performance standards or other control techniques, such a system might prove workable for certain estuarine areas.

While none of the above techniques have been widely adopted, significant experimentation and success has stimulated their development. Each technique has disadvantages as well as advantages and none is the end-all answer for improving land or estuary management. Other techniques such as "marsh-banking" are due to see application as part of Oregon's coastal management program. Preferential tax assessment and open space may also serve as useful adjuncts. Whatever the combination of techniques used, it is clear that estuarine management will not be optimal from anyone's perspective while zoning is the primary development control technique in use.

The most significant action that Lincoln County could take in the near future with regard to estuarine resources would be to establish an estuary management center for the three major county estuaries-Alsea, Yaquina and Siletz. Such a center was recommended by the Oregon Coastal Conservation and Development Commission and is likely to be an element of the state coastal zone management program. With an active task force and planning commission, such a center could readily be established and perform the following functions:

> ...coordinate information about planning and regulation and ... provide for data storage, interpretation, research education activities, meetings and hearing procedures. The management center recommended herein could be established as part of an existing office such as the county planning department.[81]

The management center would be the natural location for development of the estuary information system and impact assessment coordination. It would provide in one location, identification of all activities taking place in the estuarine area. The center could coordinate local,

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[81]Oregon Coastal Conservation and Development Commission, Summary Final Report 1975, March 31, 1975, p. 15.

state and federal actions which effected the estuary and act as the local permit information and coordination center. According to the Oregon Coastal Conservation and Development Commission funds for the center would be provided by those local, state and federal agencies who would benefit from the coordination activities provided. Coastal zone management funds from an implementation grant could be used for such a project. Establishment of an estuary management center is a logical step in movement toward increased local involvement in the estuarine management process.

CONCLUSIONS

1. Though Northwest Natrual Gas Company has lost its Alaskan LNG supply, the LNG facility will be built (without the wharf and LNG unloading system) and operated as a peak-shaving plant, until such time as a new supply of LNG can be obtained (Section 1).

2. The economic impact of the LNG plant on the region will be very small, though tax revenues generated will be high in relation to services supplied (Section 2).

3. Economic benefits associated with the availability of LNG revaporization energy will only apply if the facility operates with a base-load gas output; as a peak-shaving plant, these potential induced benefits will not be possible (Section 2).

4. Environmental impact assessments for the LNG project were too narrow, sometimes conflicting and too late (Section 3 and 4).

5. The water quality impact of an LNG spill is expected to be negligible, due mainly to its low density and high volatility at normal ambient temperatures. There have been, however, no research efforts to sustain these expectations (Section 3).

6. The potential for induced industrialization as a result of LNG revaporization energy availability will put significant development pressure on the adjacent Sally's Bend tideflat area, 25% of which is presently zoned for marine industrial use (Section 3).

7. The foremost hazard associated with LNG is the flammable vapor cloud which would be produced in the unlikely went of a large LNG spill. Water spills would present the greatest hazard. The cloud will not "flash" or explode if ignited, but will burn rather slowly at the edges (Section 1 and 3).

8. Operated as an import terminal, the LNG facility is compatible and even complimentary to most present and planned estuary uses. As a peak-shaving plant, the facility is not complimentary and is essentially incompatible (Section 3).

9. The environmental management regime for the Yaquina Bay area is fragmented, often single-purpose oriented, and uncoordinated. The only body with broadbased knowledge and interest in the estuary is the Yaquina Bay Task Force, and they lack legal power and do not significantly influence decision-making.

10. The single most important factor in choosing Yaquina Bay as Oregon's LNG importation center is the proximity (7 miles) of an over-sized gas main which runs from Toledo to the central Willamette Valley. This pipeline was installed in 1965 in anticipation of success in offshore gas exploration which was in progress at that time. Other favorable factors included proximity of the site to the ocean and the low population density of the area.

RECOMMENDATIONS

1. A process to ensure comprehensive environmental, economic and social impact assessment and evaluation should be established. Such a process should apply to any significant development or preservation proposal and occur in early planning stages.

2. An information system for Yaquina Bay estuary should be developed. This system could be the basis for improved estuary management, providing usable information to the public as well as local, state and federal agencies.

3. An estuary management center for Lincoln County should be established as soon as possible. Such a center would be the focal point for coordination of local, state and federal activity in each estuary, including impact assessment, information collection and storage, public education, and meetings and hearings.

4. Alternatives to zoning an an estuary management technique need to be fully investigated. This might include performance standards, impact zoning, transferrable development rights and others.

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