B. DRAINAGE AND EROSION

1. Existing Conditions

a. Project Site

1) Surface Runoff

During the course of the site investigation (Appendix A), it was noted that there has been considerable erosion of the terrace deposits near the edge of the bluff in the area between the outfalls for the existing facilities and the Alexander Marine Research Laboratory. This erosion appears to be the result of surface runoff and/or spill of saltwater from the existing facilities, and additional areas of erosion may have been present at the bluff south of the Raceway Tanks prior to the recent placing of fill in this area.

Increased runoff should be expected as a result of the increased area of impervious surfaces (structures) and the reduced permeability resulting from compaction along the dirt and gravel roads. The arrangement of roads also would tend to intercept sheet flow and concentrate it near the area where the erosion has been identified (Figure 8). The open tanks catch some rainfall and discharge it to the outfall system along with the seawater. However, erosion appears to have been a significant problem at the existing facilities in the past, and erosion control will be important in the design of the expansion area.

2) Spills from the Saltwater Tanks

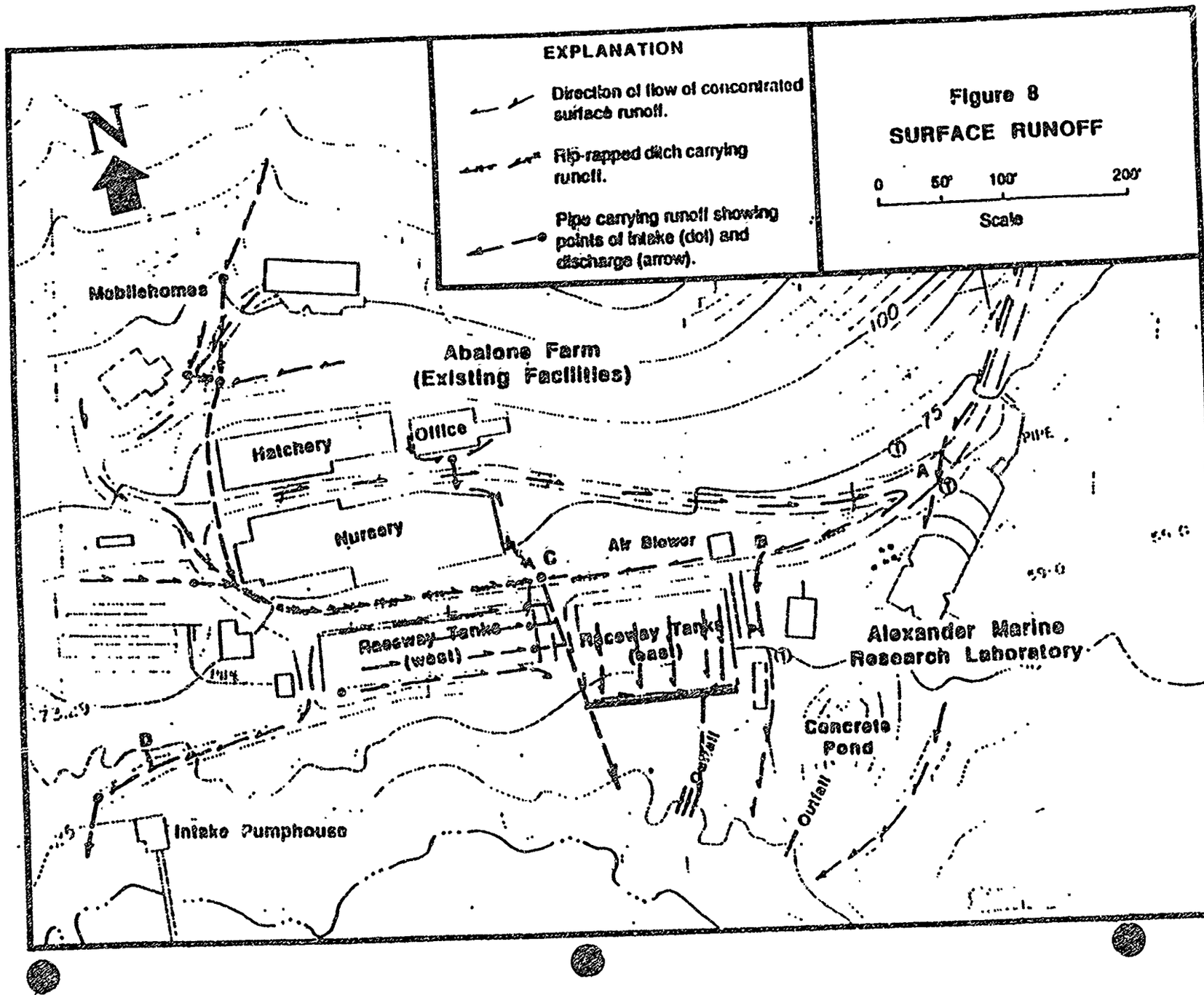
Discussions with Mr. Frank Oaks indicate that they have had problems in the past with plugging of the discharge with resulting overflow from the tanks. This has occurred for various reasons including abalone escaping to the discharge piping and growing to a size that plugs the pipe. As a result, they have been continually modifying the discharge system to utilize more open concrete drains that can be easily cleaned and limit the use of pipe to short sections where open drains are not feasible. This has substantially reduced plugging.

3) Erosion at the Outfalls

Erosion of the bluff resulting from discharge from the outfall pipes at the site does not appear to be a significant problem. The outfall from the existing facility discharges directly to a gravel or rocky beach (Figure 4 top left), and erosion is insignificant. The outfall from the Temporary Tanks (Figure 4, top right) discharges onto rock in an area of highly resistant sandstone, and present and future erosion is probably insignificant.

4) Seepage at the Bluff

In addition to erosion from surface runoff, there is a zone of extensive seepage in the bluff seaward from the large concrete pond at the Alexander Marine Research Lab ("artificial fill" on the geologic map). This seepage apparently comes from water leaking from the pond and migrating laterally along the top of the bedrock surface (base of the more permeable terrace deposits) to the face of the bluff where it contributes to the otherwise natural erosion of the bluff.



b. Access Route

The access route to the existing facilities and the proposed expansion cross an area identified as a "wetland" and an Environmentally Sensitive Habitat on the Combining Designations Map 2 for the Estero Planning Area in the Coastal Zone Land Use Element. While no new development is proposed in or adjacent to this "wetland", potential damage from erosion along the access route and sedimentation in the "wetland" is a concern.

The extent of the identified "wetland" as interpreted by the EIR consultant is shown on Figure 9 along with the drainage characteristics of the area along the access road and the project site. It should be noted that no studies have been conducted on the "wetland" as a part of the preparation of this Expanded Initial Study, and the boundary shown is the consultant's interpretation of the extent of that habitat based primarily on topography. Points to note include:

- The existing facilities and the expansion area are separated from the "wetland" by a primary drainage divide, and no runoff from these facilities enters the "wetland".
- Runoff from the slopes above the access road is primarily by sheet flow to the road where it is concentrated in ditches along the upslope side of the road. The concentrated runoff flows to the nearest gully where it enters the "wetland".
- Examination of the ditches along the road indicates that erosion is insignificant due primarily to the presence of hard, resistant sandstone at the surface in the road cuts.
- Examination of the gullys where the concentrated runoff enters the "wetland" indicates that sedimentation is also insignificant. This is also apparent from the detailed topographic map (Figure 9) which shows no indication of the accumulation of sediment (i.e., small alluvial fans) at the ends of the ditches.

Based on these observations, erosion along the access road and downslope sedimentation in or adjacent to the "wetland" has been insignificant. Geologic conditions along the ditches are such that this condition should continue.

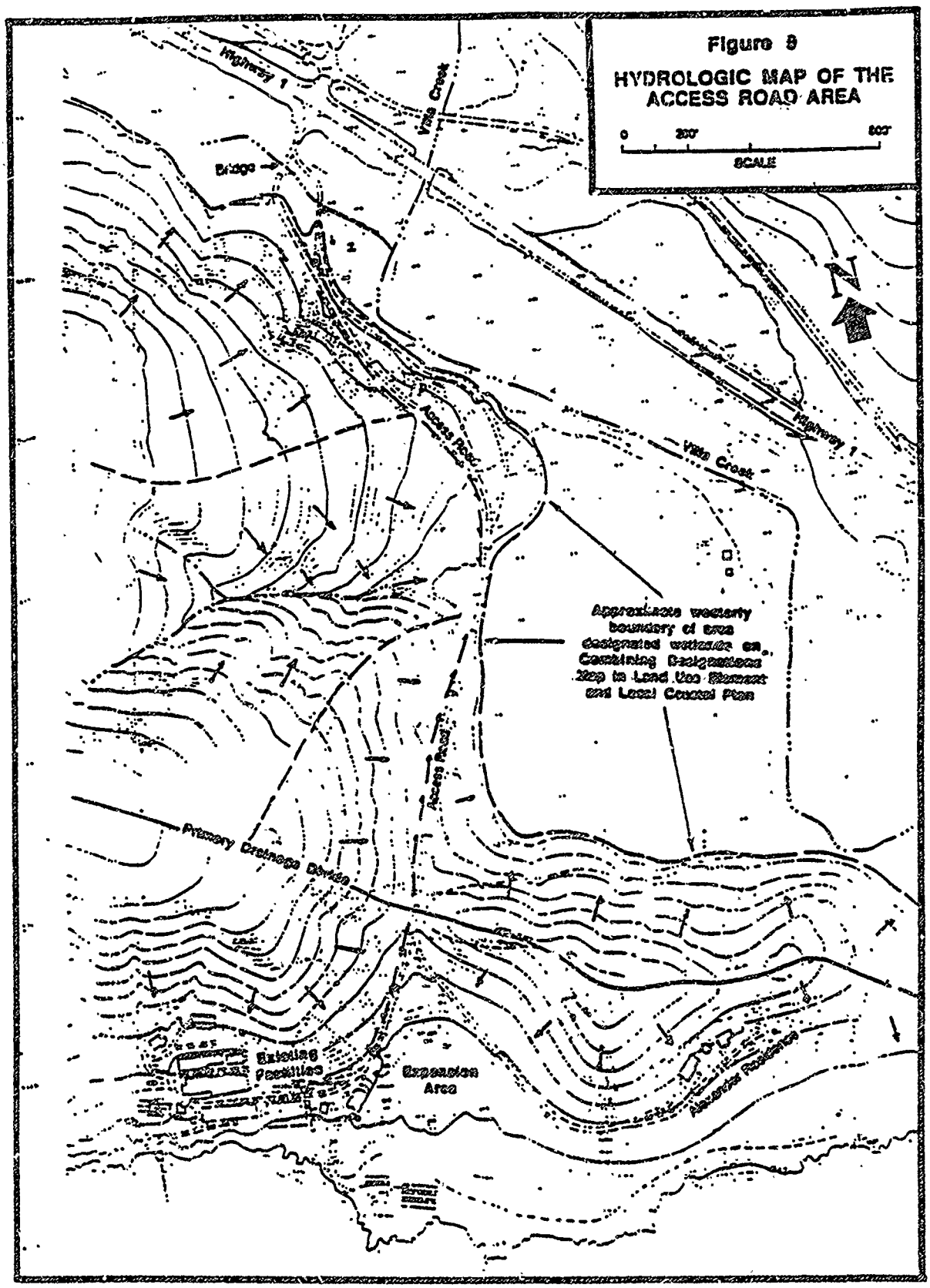
2. Project Impacts

a. Project Site

Runoff has been increased and concentrated in the area of the existing facilities, and erosion of the terrace deposits at the top of the bluff has been significant in some areas. The proposed facilities will also concentrate runoff, and measures should be taken to collect and convey this runoff over the bluff in a way that minimizes erosion.

Control of runoff concentrated on the steep access road to the intake pumphouse will also be important. This runoff is now collected in an open 8-inch pipe near the end of the road and discharged onto bedrock near the base of the bluff. The primary problem with this facility is that the terrace deposits erode easily, and the sediment in the runoff may plug this pipe in a heavy storm.

Spills of seawater from the raceway tanks has been reduced by utilizing open concrete drains to the greatest extent feasible. However, future plugging of the discharge system



cannot be precluded and precautions should be taken to catch spilled seawater before it reaches the edge of the bluff.

The loose fill at the edge of the bluff southerly of the existing raceway tanks is susceptible to erosion, and should be planted as soon feasible (i.e., at the onset of the wet season).

The seepage of water leaking from the large pond at the Alexander Marine Research Lab is also contributing to erosion of the bluff. It is also possible that this seepage could develop into piping with a major washout of the terrace deposits and the overlying embankment on the seaward side of the pond. The process would be much the same as the failure of the Baldwin Hills Reservoir, but on a much smaller scale.

b. Access Road

Examination of conditions along the access road indicates that erosion and downslope sedimentation have been insignificant, and geologic conditions indicate that this condition should continue with implementation of the proposed expansion.

3. Mitigation Measures

Potential impacts resulting from erosion by concentrated runoff or spills of seawater from the raceway tanks can be avoided or minimized by implementing the following mitigation measures:

General Recommendations:

- Concentrated runoff from the site shall not be allowed to flow over the coastal bluff, but shall be intercepted before reaching the bluff and diverted to control devices.
- All areas of recent fill along the edge of the bluff shall be planted to fast-growing grasses at the onset of the wet season to minimize first-year erosion. Native, salt-tolerant vegetation should be introduced as rapidly as feasible for long-term stability. A list of species is included on page 6 of Appendix B.
- Facilities to discharge collected runoff and seawater from the tanks on the site shall be constructed so that the released water does not impact on the terrace deposits, but is released onto bedrock or the gravel beach. For most locations at the site, piping should extend down the bluff to an elevation of approximately 20 feet above mean sea level.
- Discharge facilities should be constructed so that they can be periodically modified to accommodate changing bluff configurations. The large diameter PVC pipe now in use would appear to be ideal for this purpose.

Specific Recommendations for the Existing Abalone Farm Facilities:

- Drainage control shall be improved at Points A and B (Figure 8), north of the Alexander Marine Research Laboratory, so that concentrated runoff is conveyed westerly along the access road to the primary collection point C rather than crossing the road and flowing to the bluff along uncontrolled channels.

- An open concrete "V" ditch, similar to that along the southerly edge of the east raceway tanks, shall be installed southerly from the west raceway tanks. This ditch could be located in the center or along the southerly edge of this access road. The ditch shall be designed to carry the total seawater flow to these tanks in the event of a spill, or runoff from the local area for a 100-year storm, whichever is greater. The area between this access road and the bluff (now loose fill) shall be graded to direct surface flow back to the "V" ditch to the extent that this is feasible.

- Drainage facilities along the road to the intake pumphouse should be revised as follows:

  - The intake to the pipe at the bottom of the road shall be improved to include a concrete box configured to minimize sediment clogging (i.e., edges raised above road level but below the level of the berm at the south edge of the road).

  - Concentrated runoff from above the steep segment of this road (easterly of Point D on Figure 8) shall be intercepted and conveyed to the box inlet at the bottom of the road by a pipe buried in the roadway. (This improvement is intended to minimize runoff flowing down the steep segment of the road and consequent erosion and sedimentation at the box inlet.)

  - Runoff from the steep segment of the road shall be channeled in a non-erosive device located in the center of the road or on the inland side of the road, and conveyed to the box inlet at the bottom end of the road.

  - Discharge from the pipe from the box inlet shall be onto bedrock and not onto the softer terrace deposits (i.e., at or below elevation approximately 20 feet).

Specific Recommendations for the Abalone Farm Expansion Facilities:

- Control of excess surface runoff or a spill of seawater from the expansion facilities shall be controlled by providing an open concrete ditch along the southerly perimeter of the facility.

- Diversion and control of runoff flowing toward the expansion facility shall be governed by the General Recommendations above.

Specific Recommendations for the Alexander Marine Research Laboratory:

- Leakage from the concrete pond shall be stopped or reduced to a level of insignificance, or the use of this facility shall be terminated. Seepage at the bluff is substantial, and piping, with a major increase in the volume of flow and the possible collapse of the terrace underlying the seaward side of the pond, could develop at any time. The result could be a major scar on the coastal bluff.

- If use of this facility is to be terminated, then it shall be removed and the site returned to its original configuration to the extent that this is feasible.

- The drainage course along the southeasterly side of the concrete pond shall be improved to conform to the General Recommendations listed above.

C. BIOLOGICAL RESOURCES

1. Existing Conditions

a. Terrestrial Biology

A vegetation survey of the Abalone Farm property has been conducted by Drs. V. L. Holland and David Keil, and the report of their investigation is included as Appendix B. Terrestrial plant communities identified at the site include coastal valley grassland on the coastal terrace, coastal scrub on the hillsides above the coastal terrace, sea bluff coastal scrub on the headlands and the fringe of the coastal terrace, and communities of introduced weedy species (anthropogenic communities) in disturbed areas near the existing facilities. The individual species present in these communities are discussed in detail in Appendix B. No species listed by the state or federal governments as endangered, threatened or as a candidate species, or species listed by the California Native Plant Society as rare and/or endangered were identified on the site.

b. Marine Biology

A survey of the marine environment at the site has been conducted by Dr. Fred L. Clogston, marine biologist, and the report of this investigation is attached as Appendix C. This report describes the intertidal and near-shore habitats and their biota.

2. Project Impacts

a. Terrestrial Biology

Implementation of the proposed project will result in the destruction of the vegetation on the marine terrace within the area of the proposed expansion. This area includes no known "rare and endangered species" and is not in conflict with Section 23.07.176, Terrestrial Habitat Protection in Sensitive Resource Areas. Impacts due to loss of coastal grasslands are, therefore, insignificant.

The terrestrial biological report also identifies erosional problems at the site. These are addressed above in the Drainage and Erosion section, and mitigation measures are required.

b. Marine Biology

The marine biological investigation did not identify any areas of existing or potentially significant impacts on the marine environment as described in Section 23.07.178 of the CZLUO. The report also notes that erosion of the coastal bluff has occurred in the past, but that the system to control runoff and spills from the tanks now in use and proposed for

the expansion area should minimize additional effects. Excessive erosion of the bluff and the introduction of silt into the marine environment may be deleterious in the short-term,. However, affected areas normally recover quickly, and the effect is adverse but not significant.

All reasonable means should be taken, however, to minimize erosion of the bluff, and measures to minimize future erosion are included in the drainage and erosion section of this Expanded Initial Study.

3. Mitigation Measures

No significant impacts to biological resources have been identified, and no mitigation measures are required. Use of native vegetation in the control of erosion is included in the mitigation measures in the Drainage and Erosion section.

D. ARCHAEOLOGICAL RESOURCES

1. Existing Conditions

Archaeological surveys of the expansion area have been conducted by Mr. Robert O. Gibson (June 18, 1988) and Mr. W. B. Sawyer (August 25, 1988). Gibson's investigation consisted of a record search and surface investigation, and Sawyer's investigation included subsurface testing recommended by Gibson. The subsurface investigation indicated that the site identified by Gibson is smaller than suggested by the surface examination, and that the site does not extend southerly of the cut bank at the northerly edge of the area partially graded for expanding the raceway tanks.

2. Project Impacts

The subsurface investigation indicates that grading south of the cut bank at the northerly edge of the area graded for expanding the raceway tanks will not impact archaeological resources, and monitoring of grading in this area is not required. However, archaeological remains may be present in the subsurface north of the cut bank, and grading in this area should be monitored.

3. Mitigation Measures

Additional grading north of the cutbank in the expansion area (i.e., more than 20 feet north of elevation point 58.0 on Figure 2) shall be monitored by an archaeological team, including a Native American, to collect any archaeological materials that may be encountered.

E. VISUAL CONSIDERATIONS

1. Existing Conditions

The site is visible to northbound travelers along a relatively short section of Highway 1 extending from approximately Cayucos Point northwesterly for approximately 3/4 mile (Figure 10). Along this segment of the highway, the distance to the site varies from approximately 1.5 miles to 3/4 mile.

The visibility of the site from Highway 1 is illustrated by the photographs on Figure 11. View A is from the easterly edge of the site back toward Highway 1 (Figure 10). The highway is visible as a faint alignment of tonal differences, and three large RV's are distinguishable as white dots. View B on Figure 11 is from the nearest point along Highway 1 from which most of the existing facilities are visible. In this view, the Alexander residence is moderately prominent. The Abalone Farm is moderately visible, and the only structures that can be identified are the nursery buildings.

The maximum possible view of the site is from Point C on Figure 10. This point on the highway affords the maximum potential to "see around" the view-blocking ridge just west of the Alexander residence. The azimuth of the view from this point is approximately 281°. Figure 12, Relative Visibility, has been prepared using this viewing angle aligned across the view-blocking ridge on the easterly side of the site and also across the ridge above the access road to the existing facilities. Areas defined are: 1) those that are visible from Point C on Highway 1; 2) those that are not visible; and 3), those areas within which structures 10 feet high would not be visible. The temporary mounds left from the partial grading of the site are ignored in this analysis.

2. Project Impacts

Based on the visibility of the expansion area as shown on Figure 12 and the height of the raceway tanks of approximately 4 feet, the proposed project will not be visible from Highway 1. The existing facilities, however, are moderately visible, and the nursery buildings can be identified from the highway. This visual effect is adverse, but not significant in that the visible structures are not significantly different from agricultural structures that are more prominently visible from Highway 1.

3. Mitigation Measures

No significant visual impacts have been identified, and no mitigation measures are required by CEQA. However, the site is within a Sensitive Resource Area under the Local Coastal Plan, and the intent of the standards relating to this Area is to minimize all adverse visual effects. As a result, screens of cypress along the easterly boundary and in front of the nursery buildings (Figure 12) have been included in the landscaping plan for the project. These trees have been planted (bottom of top photo on Figure 11), and a drip irrigation system installed. These trees will provide screening of the project in the future.

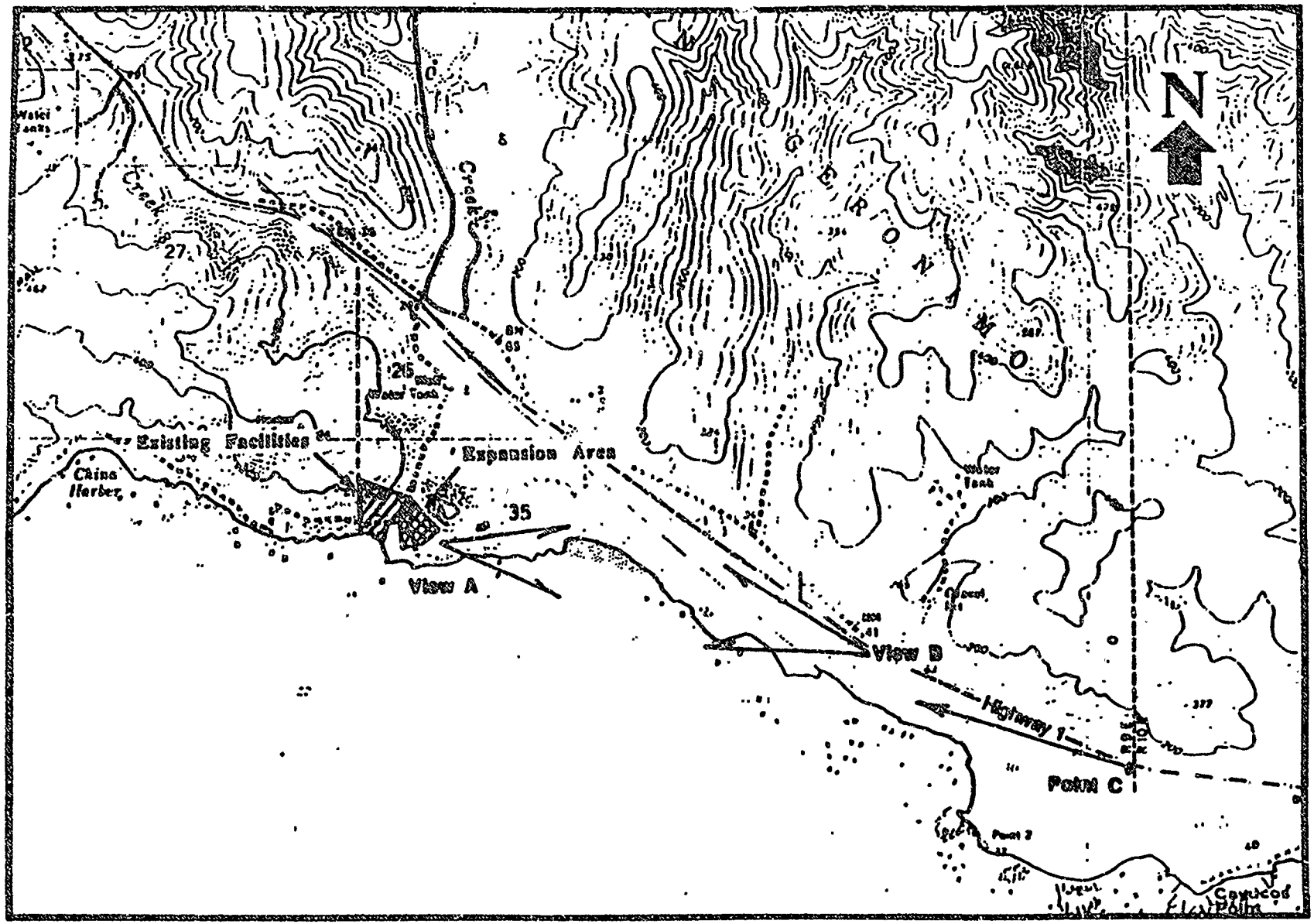
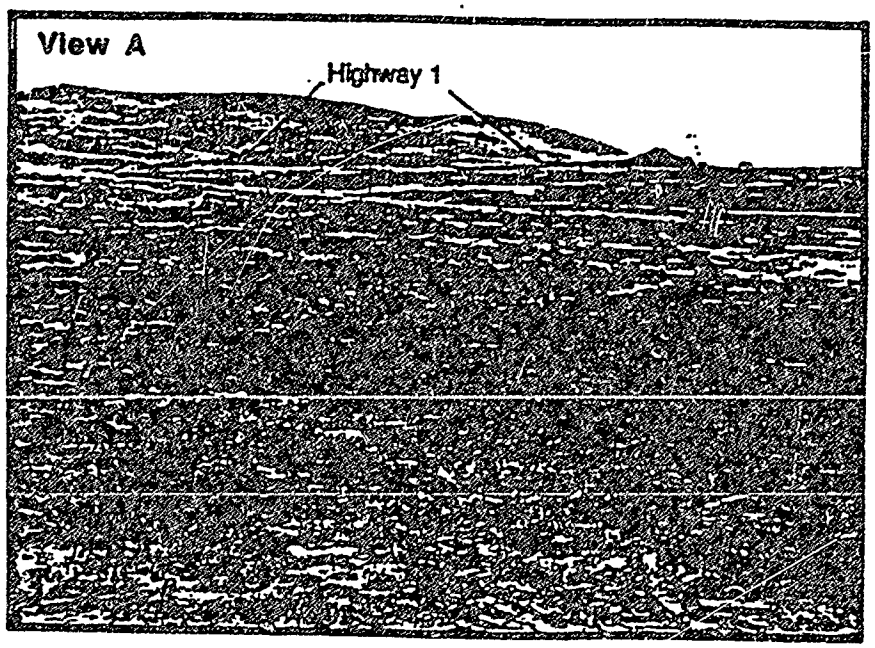


Figure 10. Index to Views from/to Highway 1. Base from USGS Cayucos Quadrangle, culture current to 1965. Scale: 1" = 2,000'



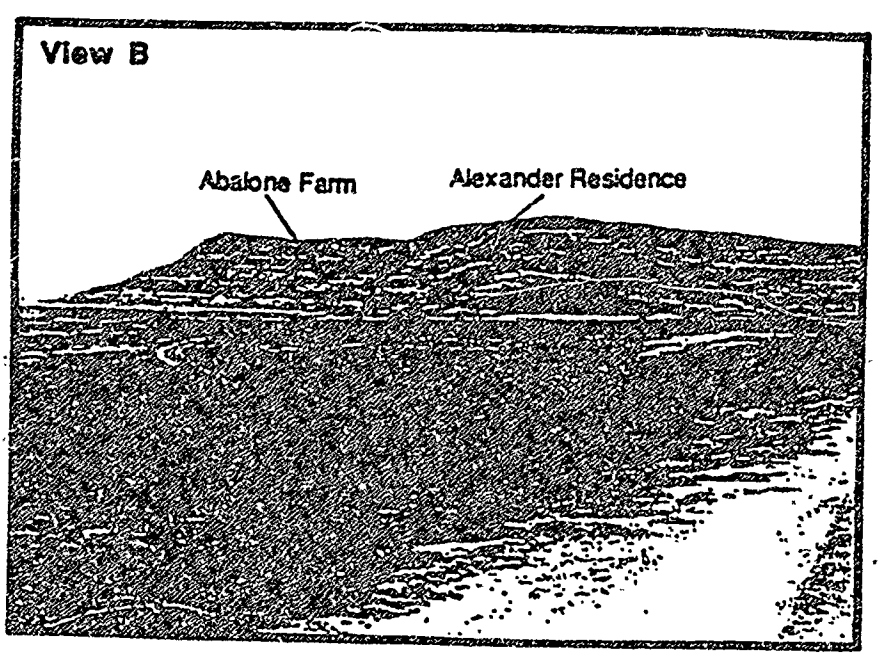
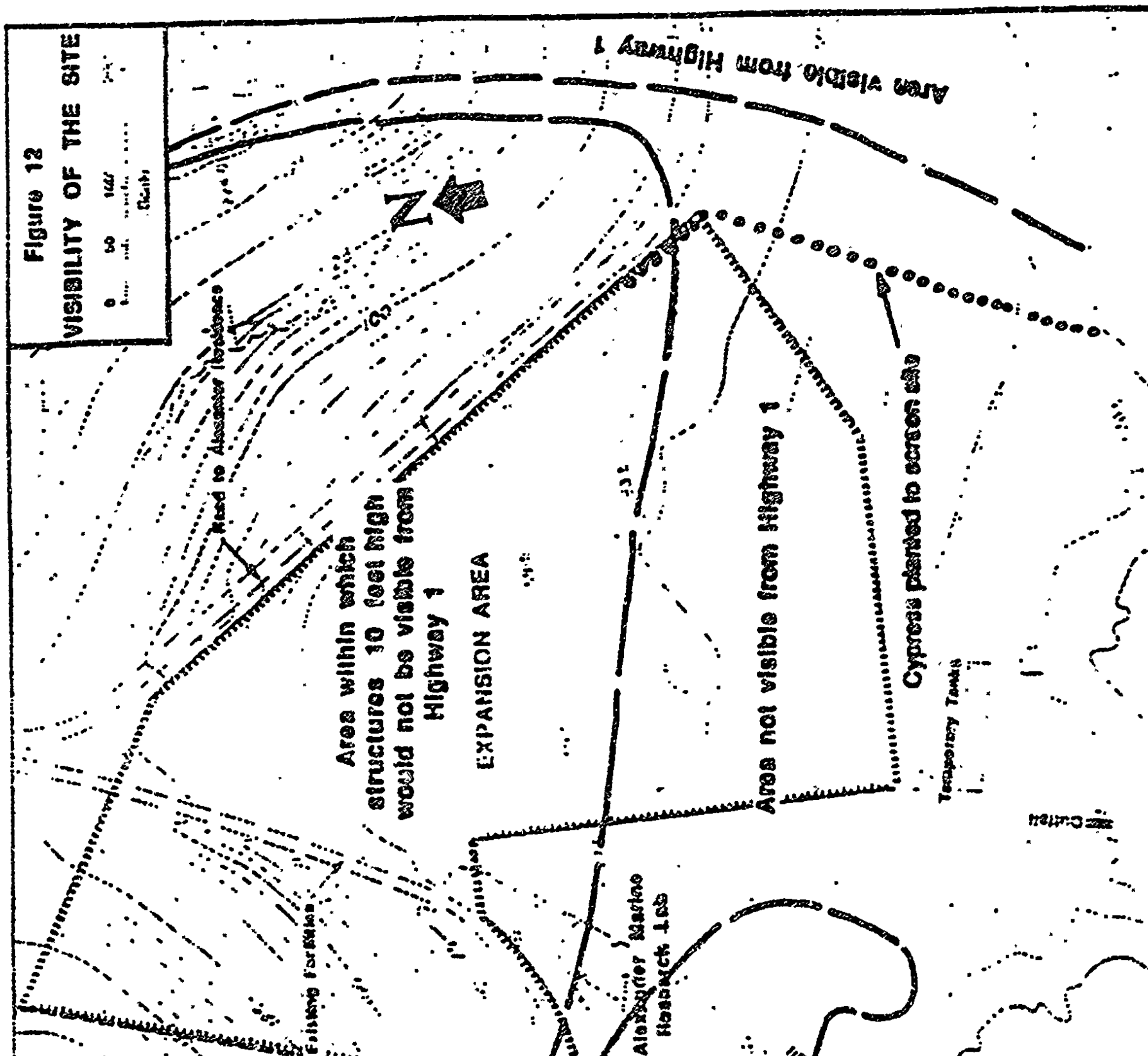


Figure 11. Views of the site from Highway 1 (bottom) and of Highway 1 from the site (top).



F. TRAFFIC

1. Existing Conditions

The number of people presently employed at the site in any one day and that may generate traffic on Highway 1 varies considerably depending on the work load, the number of part-time people, students from Cal Poly working on senior projects, etc. However, based on a worst-case condition, the present peak-day employment at the Abalone Farm is estimated by the applicant to be approximately 25 persons.

2. Project Impacts

Implementation of the proposed project will increase worst-case, peak-day employment to approximately 31, or an increase of 6 employees. Assuming all the additional employees enter and leave the site during the morning and evening peak-hour traffic periods, peak-hour traffic would be increased by 6 trips. Peak-hour traffic along Highway 1 in the vicinity of Villa Creek is approximately 1,200 vehicles per hour, and the addition of 6 additional trips (0.5%) will be insignificant.

3. Mitigation Measures

No significant impacts to traffic have been identified, and no mitigation measures are required.

G. AIR QUALITY

1. Existing Conditions

a. Project Equipment

The existing facilities generate emissions primarily by the use of diesel powered pumps used during power outages. The characteristics of these pumps are as follows (Frank Oaks):

Use of Pump	Horsepower
Primary seawater intake	125
Circulation	25
Air blower	30

The primary seawater intake pump is critical if the abalone are to survive through a power outage, and this pump is tested for approximately 2 hours each week. The remaining pumps are not critical, and these are not tested on a regular basis. The average annual use of the primary seawater pump is approximately 8 periods of 4-hours each per year. The other pumps are not normally used unless the outage is expected to last for more than 4 hours. However, for worst-case conditions, existing emissions are estimated below assuming all back-up pumps are used during the outage. Existing emissions, based on EPA AP-42, 4th Edition (1985) Table 3.3-1 assuming a load factor during testing of the primary pump of 10% and load factors during use of 80%, are as follows:

	Total Emissions (tons/year)			
Equipment	HC	NOx	SOx	CO
Primary seawater intake:				
Testing	0.002	0.020	0.001	0.004
Operation	0.004	0.049	0.003	0.011
Circulation	0.001	0.010	0.001	0.002
Blower	0.001	0.012	0.001	0.003
Totals	0.008	0.091	0.006	0.020
Total for Planning Area	979.2	568.0	44.2	9,848.2
% of Planning Area Emissions	0.0008	0.02	0.01	0.0002

b. Mobile Emissions

Emissions from Highway 1 traffic constitute the following percentages of total emissions (1985 APCD Inventory) in the Estero Planning Area:

Pollutant	Percent of Total Emissions in the Estero Planning Area
Reactive Hydrocarbons	7.2%
Particulate Matter	0.6%
Oxides of Nitrogen	3.8%
Sulfur Oxides	8.2%
Carbon Monoxide	12.0%

2. Project Impacts

a. Project Equipment

Implementation of the proposed project will add one 75 horsepower air blower back-up diesel motor which will affect on-site emissions as follows:

	Total Emissions (tons/year)			
Equipment	HC	NOx	SOx	CO
Existing equipment	0.008	0.091	0.006	0.020
Additional blower	0.002	0.030	0.002	0.006
Totals	0.010	0.121	0.008	0.026
Total for Planning Area	979.2	568.0	44.2	9,848.2
% of Planning Area Emissions	0.0010	0.02	0.02	0.0003

Emissions from existing and proposed equipment at the site are clearly insignificant.

b. Mobile Emissions

The project will increase traffic on Highway 1 by 0.5% which will increase total emissions in the Estero Planning area as follows:

Pollutant	Percent of Total Emissions in the Estero Planning Area
Reactive Hydrocarbons	0.036%
Particulate Matter	0.003%
Oxides of Nitrogen	0.019%
Sulfur Oxides	0.041%
Carbon Monoxide	0.060%

Based on the above, potential impacts to air quality are insignificant.

3. Mitigation Measures

No significant impacts to air quality have been identified, and no mitigation measures are required.

REFERENCES

Asquith, D. O., 1983, *Rates of Coastal Bluff Retreat, Pismo Beach, California*: Coastal Zone '83, p. 1195-1207.

Campbell, K.W., 1981, *Near-source attenuation of peak horizontal ground acceleration*: Bull. Seis. Soc. Amer., v. 71, p. 2039-2070.

Ernstrom, D.J., 1984, Soil Survey of San Luis Obispo County, California, Coastal Part: U.S. Department of Agriculture, Soil Conservation Service.

Hall, C. A., 1974, *Geologic Map of the Cambria Region, San Luis Obispo County, California*: U.S. Geological Survey Map MF-599.

Kuhn, G. G., and F. P. Shepard, 1984, *Sea Cliffs, Beaches, and Coastal Valleys of San Diego County: Some Amazing Histories and Some Horrifying Implications*: University of California Press, 193 p.

PG&E, 1988, *Final Report of the Diablo Canyon Long Term Seismic Program*: prepared for the Nuclear Regulatory Commission, July 1988.

Sawyer, W. B., *Archaeological subsurface testing, the Abalone Farm extension, APN 046-151-009, Cayucos, California*: prepared for the Abalone Farm, Inc. August 25, 1988.

Appendix A

ENGINEERING GEOLOGIC REPORT

THE MORRO GROUP

September 20, 1988

Office of the Environmental Coordinator
County of San Luis Obispo
County Government Center
San Luis Obispo, CA 93408

ATTN: Mr. John Nall

SUBJECT: Engineering Geologic Report for Bluff Retreat Setback, the Abalone Farm

Dear Mr. Nall:

The following engineering geologic report has been prepared to conform with the requirements of Section 23.04.118b of the Coastal Zone Land Use Ordinance. In this regard, it should be noted that the list of required information given in this ordinance is generic, and covers all items that may be of use in California. Some items are not available or of limited use in the evaluation of bluff retreat in this area, and our report concentrates on the information that is available.

A. EXISTING GEOLOGIC CONDITIONS

1. Geologic Units

The proposed project is located on the coastal terrace approximately 1/2 mile west of the mouth of Villa Creek and one mile west of Highway 1. This area has been mapped by Hall (1974) at a scale of 1"=2,000 (Figure 1), and the bedrock in the area is Cretaceous sandstone which is the dominant unit underlying the coastal bluffs from the area of the site north to the community of Cambria. This unit is composed primarily of medium grained, arkosic sandstone that is hard, resistant to erosion, and stable under most geologic conditions. However, thin beds of siltstone and claystone are present in some areas between the massive to thick bedded sandstones, and overall resistance to erosion is primarily related to the distribution of these weaker units.

The detailed geology of the bluff at the site is shown on Figure 2 at a scale of 1"=100'. The area covered (study area) extends easterly approximately 300 feet from the project (Expansion Area), and westerly to include all of the area of the existing facilities at the Abalone Farm and the Alexander Marine Research Laboratory. Geologic units distinguished include the terrace deposits. (approximately 120,000 years old), and units of the Cretaceous sandstone (approximately 100 million years old) including massive sandstone (SS on map), sandstone with minor shale beds (SS+SH), and thicker units of shale and siltstones that can be mapped individually. The relative resistance to wave erosion of the Cretaceous sandstone decreases with increasing content of shale and siltstone.

The terrace deposits are composed of silty and clayey sands that are only partially consolidated and much more susceptible to erosion than the underlying bedrock. In the easterly half of the study area, the thickness of the terrace deposits at the edge of the bluff varies in the range of

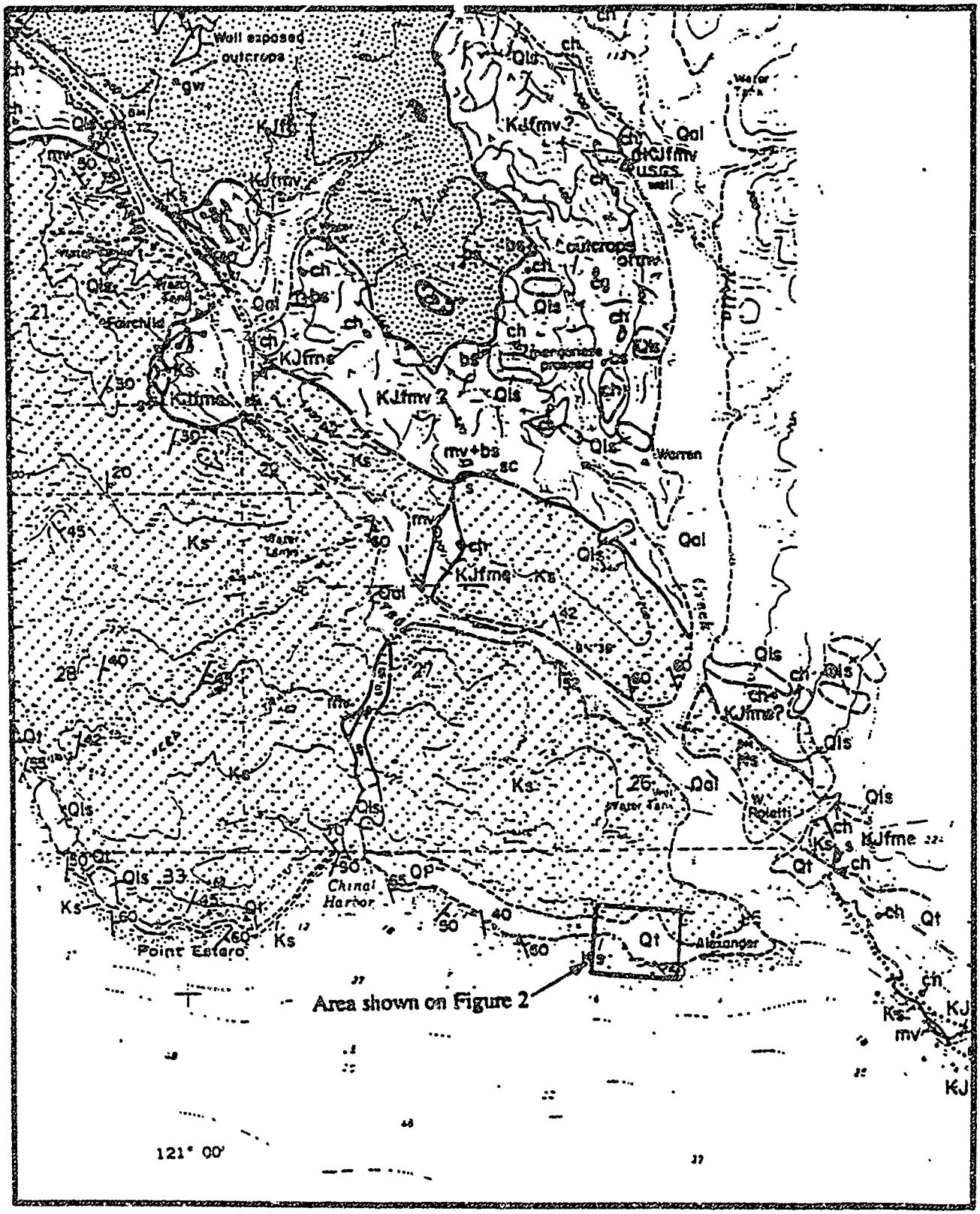
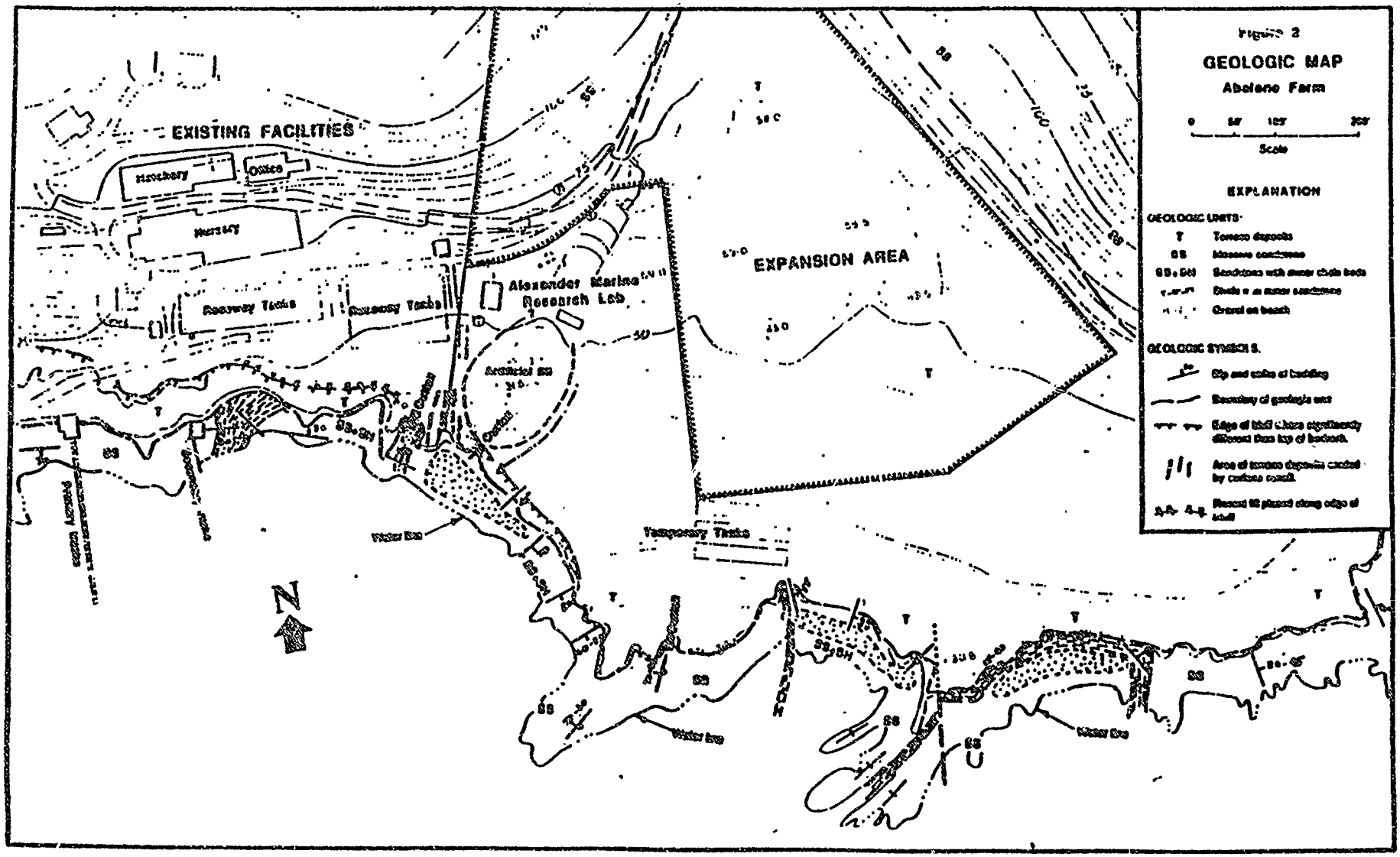


Figure 1. Geologic Index Map. From Hall, 1974. Scale: 1"=2,000'


EXISTING FACILITIES
Hatchery
Office
Nursery
Raceway Tanks
Raceway Tanks
Alexander Marine Research Lab
Artificial Bar
EXPANSION AREA
Temporary Tanks
Water Line
Water Line
Water Line
N
Figure 2
GEOLOGIC MAP
Abalone Farm
Scale
EXPLANATION
GEOLOGIC UNITS
T Terrace deposits
GEOLOGIC SYMBOLS

approximately 3-5 feet, and the top of the bedrock is consistently at an elevation of approximately 20-25 feet. However, beginning at a point westerly of the Temporary Tanks, the thickness of terrace deposits increases northwesterly along the bluff at a rate equivalent to the increase in elevation of the top of the bluff. At a point west of the south edge of the Temporary Tanks, the terrace deposits are approximately 10 feet thick. Northwesterly, near the "Artificial fill" at the Alexander Marine Research Laboratory, the terrace deposits are approximately 15 feet thick. To the west, in the area above the primary and secondary intake structures, the terrace deposits are approximately 35-40 feet thick. In these areas where the terrace at the bluff is much thicker, the elevation of the top of the bedrock is at elevation 20-25 feet as it is to the east where the terrace deposits are much thinner. This distribution of the thickness of the terrace deposits can be related to long-term rates of bluff retreat that are discussed below.

2. Geologic Structure

The orientation of bedding planes in the Cretaceous sandstone sequence at the site is shown on Figure 2 using standard geologic symbols for the dip and strike of bedding. Bedding orientation is consistent with the alignments of physical features along the bluff and the rocks offshore. The bedrock in the area is highly fractured and jointed, but the alignments of these rock features do not appear to control to any significant extent variations in the rates of retreat of the bluff. That the bedrock is fractured contributes to its erodability. However, fracture and joint patterns are not significantly affecting the locations of retreat, and the orientations of these features are not shown on the geologic map.

3. Bluff Retreat

a. General Considerations

1) Statewide Conditions

Criteria for the evaluation of coastal bluff retreat as contained in the LCP-LUO include a generic list of all possible methodologies that might be used to effectively solve the questions involved. The list is oriented toward areas of very high rates of retreat such as have been experienced in parts of Los Angeles and San Diego County. These methodologies do not necessarily apply to San Luis Obispo County. For example, Drs. Kuhn and Shepard (1984) of the University of California have compiled a "horror story" of examples of coastal bluff retreat in San Diego County. On the other hand, they include in their discussion of Methods of Study (p. 8-9) two pictures of a sea cliff north of Port San Luis in San Luis Obispo County that, between 1898 and 1945, experienced essentially no observable change (see Attachment A). The primary points to be noted are that local geologic conditions control rates of retreat, and that methodologies to evaluate rates of retreat that are applicable in one area may not be applicable in other areas.

2) Local Conditions

Coastal bluffs on the Central Coast normally include a lower section composed of bedrock with a relatively high but variable degree of resistance to wave erosion, and an upper section composed of terrace deposits that have a relatively low degree of resistance to wave erosion. Where bedrock extends significantly (i.e., 10-15 feet or more) above the zone of effective wave attack (i.e., above the shore-line angle), bluff retreat is controlled almost totally by the characteristics of the bedrock units. However, where the bedrock is low in the coastal bluff (less than 5 ft. ±), erosion at the edge of the bluff is controlled primarily by the resistance of the overlying terrace deposits, and the degree to which the beach seaward of the bluff is erodible. This condition is relatively limited on

the Central Coast, but where it is present relatively high rates of retreat are common. Examples include the bluff in north Morro Bay and southern Cayucos, Pismo Beach near the pier, and Montana de Oro just north of the mouth of Hazard Canyon where 30-50 feet of bluff was lost in the 1983 storms alone.

At the project site, bedrock is high in the bluff (20-25 feet), and retreat from wave erosion is controlled primarily by the resistance of the bedrock units. Also, the wave-cut platform is shallow for several hundred feet offshore, and numerous rocks are exposed at mid- to low-tide for distances of 300 to 400 feet offshore. This condition extends offshore for at least 1/2 mile as shown by the seaward protrusion of the depth contours on Figure 1 and the presence of kelp beds offshore. There are gravel deposits on some of the beaches along the bluff at the site. However, these are thin (a foot or so), and the sea bottom offshore can be considered as being bedrock and not easily erodible

b. Absolute Rates of Retreat

Absolute rates of the retreat of coastal bluffs can be determined from historical evidence such as photographs (aerial or ground locations) of the same area taken at different times, or survey maps of the bluff edge or survey points that have been referenced to the bluff edge. This type of evidence is normally available for areas urbanized several tens of years ago (i.e., Los Angeles-San Diego region), but it is not generally available for rural regions which include most of San Luis Obispo County. Exceptions include the Dinosaur Caves-Shelter Cove area of Pismo Beach where large-scale Caltrans aerial photographs were utilized to establish rates of retreat over the last 30 years (Asquith, 1983), the South Palisades area of Pismo Beach where a pipeline near the bluff provides a long-term line of reference, and the Pirate's Cove area of Avila Beach where near-bluff physiographic features have not been significantly altered and where rates of retreat are locally high.

These studies establish absolute rates of retreat for the Central Coast generally as follows:

Geologic Condition	Average Rate of Retreat (ft/yr)
Hard, resistant rocks (e.g., Obispo tuffs and older hard rocks)	<0.2
Medium resistant rocks (e.g., Miocene shales and siltstones)	0.2-0.4
Low resistant rocks (e.g., folded and fractures shales and siltstones)	0.4-0.8
Very low resistant rocks (e.g., landslide debris)	1.0-2.0 or higher

It should be emphasized that these rates of retreat are based on studies conducted to date, and additional studies may result in some modification of these parameters. Also, identification of the conditions involved requires local experience, and this author does not assume responsibility for the use of these parameters by others. However, there would appear to be a limitation on the range of bluff retreat rates in which bluffs underlain by a thick section 10 feet or more) of very resistant rock show no discernible rate of retreat (<0.2 ft/yr as a threshold value), and some easily erodible sections have rates of retreat averaging up to 2 ft/yr or more.

Bluffs having thin (<5 feet) or no rock section as in Cayucos may have rates of retreat that are substantially greater than those listed above. Rates of retreat in these areas tend to be highly dependent on the stability of the sand beach fronting the bluff, and methods of evaluating sand

beach stability are problematic at best.

c. Absolute Rates at the Site

Aerial photographs available in the County files and past surveys of the site have been reviewed, and no information has been identified that would further refine local rates of bluff retreat beyond those that can be assigned on a general basis. That is, available aerial photographs are at scales in the range of 1,000-2,000 ft/in, and threshold measurements of approximately 0.02 inches equate to distances of 20 to 40 feet, or the retreat that would be expected with the normal range of conditions in 50 to 100 years. These photographs, therefore do not provide useful information unless rates of retreat are substantially above normal levels.

Land surveys are sometimes of help, particularly if the site involved is in an urban area where detailed surveys have been routine. However, the project site has been a cattle ranch until recently, and detailed data from old surveys are not available.

d. Relative Rates of Retreat

Absent reliable data from which to extract absolute rates of bluff retreat for the site, this study relies on a comparison of the geologic conditions at the site with those investigated by the author where data for absolute rates of retreat are more reliable. Two basic approaches are involved:

Short-Term (a few hundred years): Rates of retreat in this time-frame can be estimated from rock characteristics and their relationship to the present characteristics of the shoreline. Given the generally resistant nature of the bedrock sandstone section at the site and the height of bedrock above the beach, rates of retreat that should be expected are in the range of <0.2 to 0.4 ft/yr at most.

Long-Term (several thousands of years): Long-term rates can be estimated from the degree of encroachment into the typical terrace section. That is, assuming that the Cayucos terrace surface, developed after a past high-stand of sea level approximately 120,000 years ago, was relatively intact at the onset of the present high-stand of sea level beginning approximately 5,000 years ago, the rate of retreat is approximately proportional to the height of the bluff (and the thickness of terrace deposits exposed in that section).

Of the above, the short-term rate of retreat (a few hundred years) is probably the only parameter of interest in the analysis of bluff retreat applicable to the proposed project. However, the long-term history of the site is of interest in that it can provide a check on the rates of retreat that have been assigned for the short term.

1) Short-Term Rates of Retreat

Based on our past experience in the analysis of bluff retreat in coastal areas of San Luis Obispo County and the characteristics of the bedrock section at the site, rates of bluff retreat should be in the range of <0.02 to 0.4 ft/yr. Higher rates cannot be totally ruled out, but there are no significant data that would suggest that abnormally high rates should be applied to the site. This range of rates of bluff retreat is distributed to the coastal bluffs at and adjacent to the site as shown on Figure 3 with one exception. The zones of relatively high shale and siltstone content located south of the existing raceway tanks and near the southeast corner of the study area are assigned a slightly higher

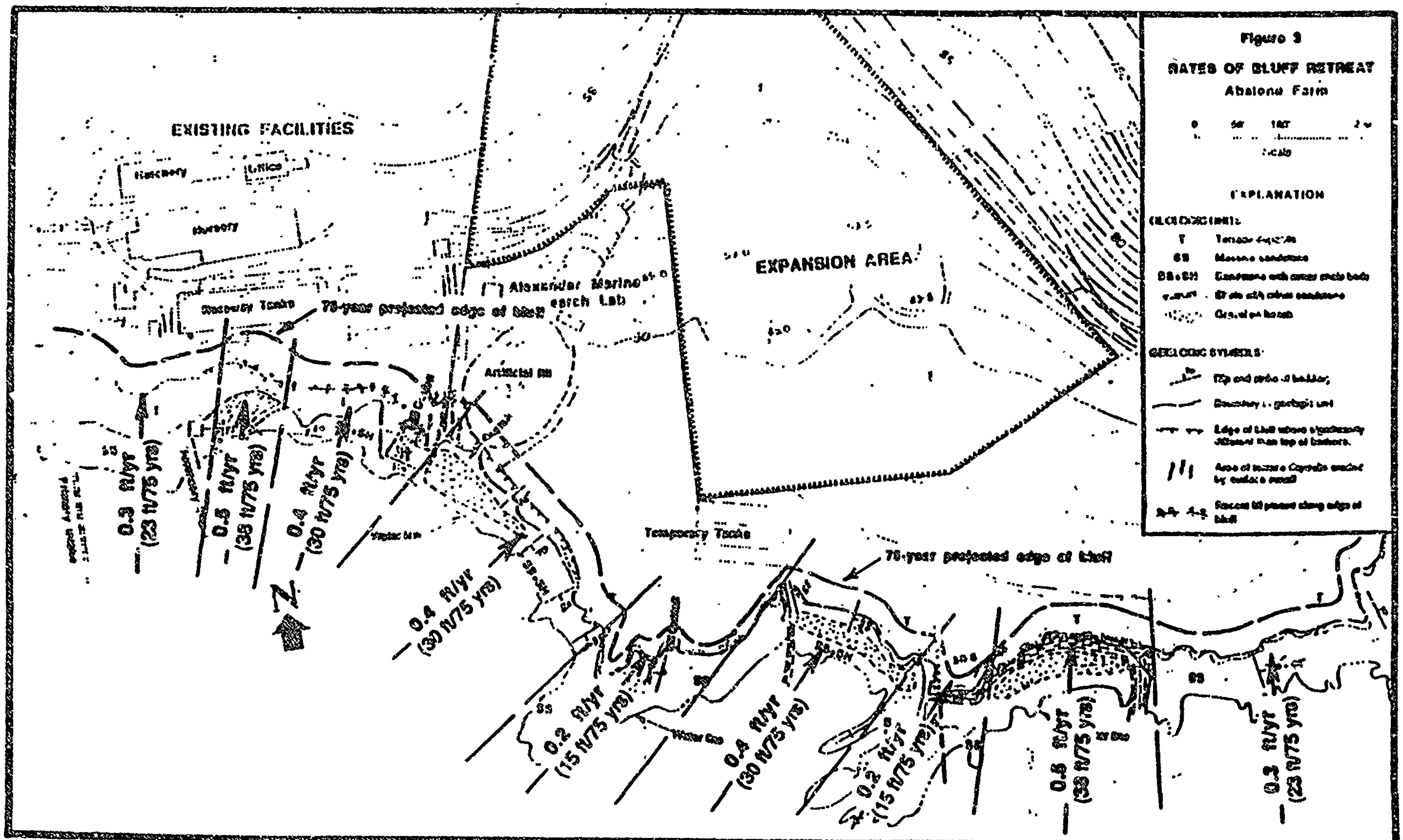


Figure 3
RATES OF BLUFF RETREAT
Abalone Farm
EXPLANATION
EXISTING FACILITIES
Hatchery
Office
Nursery
Hatchery Tanks
Alexander Marine Research Lab
Artificial fill
EXPANSION AREA
Temporary Tanks
75-year projected edge of bluff
Water line
0.3 ft/yr (23 ft/75 yrs)
0.5 ft/yr (38 ft/75 yrs)
0.4 ft/yr (30 ft/75 yrs)
0.2 ft/yr (15 ft/75 yrs)

rate of 0.5 ft/yr because of the low resistance of these units to erosion. These beds are only about 10-15 feet thick, so the period of more rapid erosion is not applicable to the entire 75-year projection interval.

The projected 75-year edge of bluff is shown on Figure 3 based on these estimated rates of retreat. This projection indicates that the project (proposed expansion area) will not be adversely affected by bluff retreat in the next 75 years. The seawater pond constructed at the Alexander Marine Research Laboratory ("Artificial fill" on map) and the existing Raceway Tanks may, however, be affected by future bluff retreat.

2) Long-Term Rates of Retreat

On a long-term basis, the site can be divided into three parts (Figure 4): 1) Segment 1: a low-level rate-of-erosion segment that extends from the easterly part of the study area to a point approximately west of the south edge of the Temporary Tanks; 2) Segment 3: a zone of higher-rate erosion of the bluff that would appear to be significantly greater than rates of erosion in Segment 1 on a long-term basis; and 3), Segment 2: a transition zone between Segment 1 and Segment 3 within which long-term erosion rates are transitional between those of Segment 1 and those of Segment 3.

Interpretation of long-term erosion rates from these data is somewhat conjectural depending on assumptions related to a typical terrace profile and the seaward extent of this terrace at the time sea level stabilized about 5,000 years ago. However, based on average rates in Segment 1 of 0.32 ft/yr and 0.4 ft/yr in Segment 3, the edge of the terrace 5,000 years ago would have been approximately 1,600 to 1,750 feet offshore from Segment 1. This is a reasonable projection considering the relatively shallow water offshore. This does not confirm that the short-term rates used above are correct, but it does indicate that they are reasonable over the long term.

3. Bluff Erosion

a. Surface Runoff

During the course of the site investigation, it was noted that there has been considerable erosion of the terrace deposits near the edge of the bluff in the area between the outfalls for the existing facilities and the Alexander Marine Research Laboratory (Figure 2). This erosion appears to be the result of surface runoff and/or spill of saltwater from the existing facilities, and additional areas of erosion may have been present at the bluff south of the Raceway Tanks prior to the recent placing of fill in this area.

Increased runoff should be expected as a result of the increased area of impervious surfaces (structures) and the reduced permeability resulting from compaction along the dirt and gravel roads. The arrangement of roads also would tend to intercept sheet flow and concentrate it near the area where the erosion has been identified (Figure 5). The open tanks catch some rainfall and discharge it to the outfall system along with the seawater. However, erosion appears to have been a significant problem at the existing facilities in the past, and erosion control will be important in the design of the expansion area.

b. Spills from the Saltwater Tanks

Discussions with Mr. Frank Oaks indicate that they have had problems in the past with plugging of the discharge with resulting overflow from the tanks. This has occurred for various reasons