MARINE SCIENCES RESEARCH CENTER
STATE UNIVERSITY OF NEW YORK
STONY BROOK, NEW YORK 11794

Recommendation for Monitoring a Borrow Pit Disposal Site

Henry Bokuniewicz

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M. J. Bowman, Acting Director

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INTRODUCTION

The burial of dredged sediments beneath the sea floor in subaqueous borrow pits was identified as a disposal alternative to open-water disposal at the Mud Dump site on the Atlantic shelf (Conner, et al., 1979). Filling of subaqueous borrow pits with dredged mud and covering, or capping, the deposit with sand would both isolate and contain the mud and restore the area to its original bathymetry and substrate (Bokuniewicz, et al., 1986). A Supplemental Environmental Impact Statement (SEIS) is presently being prepared to implement this option (U. S. Army Corps of Engineers, 1988).

Monitoring an operation at a borrow-pit disposal site may be more critical than it is at the Mud Dump for four reasons. First, this is a new technique and, second, since the site is likely to be smaller, more control must be exercised over the discharges. Third, the potential sites are closer to shore and, fourth, contaminated material will be involved.

The monitoring plan must be designed to meet three types of needs. These are:

1. the enforcement of restrictions on the time and location of the discharges and on the thickness of any prescribed cap. Violations should be detected as soon as possible so that corrective measures can be taken.

2. management of the disposal site. The site manager must know when and where to move the discharge location, when and where to cap, and when to stop filling and call for the final cover. In addition, although the enforcement personnel should be monitoring to detect violations of the rules, the manager must be watching for violations in the intent of the rules. It may be possible that the constraints that are initially established to not achieve the desired result. The manager must know if this is the case and make amendments.

3. environmental concerns regarding the release of contaminants and the effects, if any, on the ambient benthic communities.

To meet these needs, the following information is required:

1. discharged volumes
2. discharge location and time
3. contaminant levels in the dredged sediment
4. whether or not the bottom surge escapes over the time of the pit

5. form of the deposit
6. ambient levels of contamination
7. cap stabilit.

The monitoring should be as automated as possible without being unduly complicated and it should provide the required information as directly as possible, that is, with the minimum amount of analysis. Some of it would be done by the dredging contractor. The monitoring requirements might be summarized as follows:

Data	Need	Can the dredging contractor do it?
volumes	management	yes
contaminant levels	environmental	yes
discharge location	enforcement	yes
escape of surge	management, enforcement and environmental	no
form of deposit	management	possibly
contaminant release	environmental	no
cap stability	environmental	no

CHARACTERISTICS OF A MONITORING PROGRAM

To meet these needs, any monitoring program might include the following fifteen elements:

1. In preparation for the use of a site a detailed bathymetric survey (e.g., Morton, 1983) should be done on 50-foot lines with microwave navigation (or a system with the equivalent accuracy, ± 3 m). Tidal corrections should be made with respect to a known datum with real-time water level information provided by a tide gage at the site. Precautions should be taken to position the navigation equipment over the transducer, to calibrate the fathometer, to correct the depths for the draft of the transducer, and to include enough of the ambient sea floor to serve as a reference elevation for future surveys.

2. Bottom samples should be taken to characterize the initial sediment type and benthic community in and around the site. This will include the intended transects to be used for biological and chemical monitoring (see item 13).

3. A taut-mooring disposal buoy should be set in the center of the area to be filled. This should not be within 250 yards of a bathymetric contour that is 5 feet or less below the ambient sea floor.

4. Turbidity-monitoring equipment should be placed on the ambient sea floor near the rim of the pit nearest the disposal buoy.

During the open-water discharge of dredged sediment, most of the material reaches the sea floor and spreads across the bottom in a dense (1000 mg/l) slurry one or two meters thick. This can easily be detected with a transmissometer, nephelometer or a standard 200 kHz fathometer; the interface between the slurry and the overlying water is fairly sharp and it can be recorded on the standard dry paper recorder at high gain. This cloud of material collapses to the sea floor within about 20 minutes and about 200 yards from the discharge point.

The monitoring device should have the following characteristics:

a. It would consist of the sensor, a power supply, a data logger and a two-way acoustic data link.

b. It would be self-contained and capable of deployment over at least one month.

c. It would be activated by an acoustic signal from the barge when a discharge was about to occur.

d. It would respond to this signal to a receiver on the barge that the device is ready.

e. Four types of sensors are possible.

    1) Transmissometers. Shipboard based transmissometers have been used extensively to detect the surge (Bokuniewicz, et al., 1978). In-situ recording transmissometers (Bohlen, 1982) have been used around disposal sites in Long Island Sound.

    2) Nephelometers. These detect turbidity by the scattering of light rather than by the transmission, but would be similar to the use of transmissometers.

    3) A narrow beam, horizontal transducer/receiver. Shipboard based horizontal transducers have been used to detect dredged sediment slurries (Bokuniewicz, 1985; Proni and Hansen, 1981) and in situ devices are commercially available. When used in shallow water and near the sea floor however there may be problems with acoustic echos from the sea surface or the sea floor contaminating the signal.

    4) A transducer-receiver pair of devices similar to an "electric eye" in which the acoustic beam would pass from one device to the next in order to monitor the water column in between the two instruments (K. Baldwin, Ocean Engineering Program, Univ. of New Hampshire, July, 1987,

personal communication). As far as I know no such arrangements of acoustic devices have been applied in this way.

The first two sensors are definitely feasible, but would only detect the surge at the point of the instrument. The acoustic devices could be beamed over a great distance from the devices but would require some further engineering development. An extensive technical discussion can be found in Irish et al., (1988).

f. If the slurry is detected by the sensor, the device would signal the barge that a violation has occured.

g. It would remain active for 30 minutes and turn itself off automatically.

h. It would also internally record the time and sensor response of each activation so that the results could be checked when the device is recovered.

5. A current meter and wave gage might also be placed on the ambient sea floor near the site. Such equipment, however, is optional but the records might be useful if operational problems are encountered under unusual conditions.

6. Candidate dredging projects should be reviewed. The permit applicant should provide not only the usual test results, including grain-size distributions, but also geotechnical information (including porosity, shear strength and permeability consolidation coefficients) and bulk chemical analyses. The reviewer must decide whether or not

a. The contaminant levels are appropriate for disposal in the pit as specified in the SEIS.

b. The project material has sufficient strength to support the subsequent overburden and cap. In general, the material must be able to be dredged with a clamshell. (The porosity and shear strength are the relevant parameters.)

The permeability and consolidation coefficients will be used to calculate the settlement of the final deposit in order to help estimate the mass of sediment contained in the deposit from survey measurements of its volume and to estimate the volume of pore water expelled during consolidation.

7. Dredging must be done with a clamshell dredge. Barges must be pushed, not towed, to the disposal site one at a time. Smaller barges are preferable to larger barges. The barges must be stationary within one barge-length of the disposal buoy before discharge. At the beginning of the discharge, the time and the position of the barge must be recorded and the turbidity monitor (see item 4) must be activated. The barge must be held within

that vicinity of the buoy until the discharge is complete and for 30 minutes after the discharge is complete in order to receive any signal from the site's turbidity monitors. The time and position at the end of the discharge must also be recorded.

8. The operator must provide daily accounts of the number of barge-loads discharged, the volume per discharge and the mass per discharge. The volume might be estimated from empirical relationships between the barge volume and the actual volume of sediment removed. The mass must be estimated based on the displacement of the barge as calculated from its draft before and after filling. The location of each discharge and the record of the turbidity monitor must be provided daily. The site manager should review the daily records to insure that

a. discharges are occurring within an acceptable distance from the disposal buoy,

b. the turbidity sensor has not responded to the discharges.

9. Before and after surveys of the dredging site should be done and used to calculate the volume of material removed.

10. After every 25,000 cubic yards the site manager should estimate the probable configuration of the disposal mound. (Figure 1 shows radial sections showing the maximum deposit thickness along a radius from a symmetrical conical deposit of various volumes.) After every 100,000 cubic yards, a partial, precision survey of the site should be done along at least two track lines that (a) are perpendicular to each other and (b) pass through the position of the disposal buoy. The site manager should use the surveys to correct and update his or her estimate of the deposit's configuration.

11. The manager should suspend operations and relocate the disposal buoy if the highest point of the deposit reaches to within 3 feet of the level of the ambient sea floor or the level of the deposit at the pit wall comes within 5-feet of the ambient sea floor.

12. A precision survey (see item 1) must be done on 150-foot lines immediately before the buoy is moved and before and after any interim caps are emplaced. (The criteria for interim capping are discussed in the SEIS; U.S. Army Corps of Engineers, 1988). A detailed precision survey on 50-foot lines must be done before and after the final cap. The manager should use the post-operation survey to estimate the volume of the deposit of dredged sediment; the in place volume should compare favorably to the total of the mass and volume estimates. Consolidation should be calculated based on the geotechnical parameters initially provided by the contractor.

13. Biological and chemical monitoring are described in the SEIS for the borrow pit disposal option (U.S. Army Corps of

Engineers, 1988). Fitzpatrick (1983) found that metal concentrations in two genera of polychaetes peaked both in the fall and in the spring. Samples for monitoring the borrow pit disposal area, therefore, would be taken at least in the spring. Samples would be collected along a transect with a station at the pit rim and then at intervals of 500, 1000, 2000, 4000 and 8000 feet from the pit's rim. In order to eliminate the possibility of misidentifying a fortuitously-oriented regional trend as a radially symmetric trend centered at the disposal site, two radial transects running in opposite directions would be preferable. Natural populations are, of course, being collected, so that the species composition should be expected to vary among sampling periods. As a result, two genera of test organisms will be used to insure that an adequate number of organisms can be collected at any time to perform the analyses. This was the procedure that Fitzpatrick (1983) found necessary; Glycera and Nephtys were used. Sampling would begin before the first use of the disposal site, continue during the active life of the pit and following the final cap. Another transect will be chosen at a nearby pit that has not been designated as a disposal site to act as a reference for interpreting the results of the sampling around the disposal site. A statistically significant elevation in contaminant levels in the test organisms near the pit would be an indicator of an adverse impact.

To be most efficient, a tiered approach is recommended in which the minimum amount of analyses are done first and depending upon those results other analyses may or may not be done (Fredette, et al., 1986). In this case, for example, the comparison might first be done between the two stations at the extreme ends of the transects only. If statistically significant difference is found then the intermediate samples would be analyzed to search for a trend. The analyses would also be tiered by selecting one indicator contaminant as the first step with the option for other analyses dependent on the initial results. Copper is recommended as an indicator contaminant.

In a survey of chemical pollution of the Hudson-Raritan estuary (Breteler, ed., 1984), copper was ranked as the contaminant that poses the largest relative threat to the marine ecosystem. Patterns in the seasonal body burden changes of copper in marine polycheates in the Lower Bay, characterize the changes for several other metals, Cd, Ni, and Zn (Fitzpatrick, 1983, Breteler, R.J., editor, 1984). In addition, background data is available from the area of interest; copper concentrations for both Glycera and Nephtys peaked at about 450 micrograms per gram dry weight in April (1981) and achieved low values of about 30 micrograms per gram in March (Fitzpatrick, 1983).

14. After the final cap, detailed, precision bathymetric surveys and a grid of bottom samples for grain size analysis should be done one week, two weeks, one month, 3 months, 6 months, one year and two years after the date of the final cap. These should be used by the site manager to monitor the

consolidation of the deposit, estimate the pore water discharge, and to monitor changes in the composition of the cap that are expected to occur as it achieves equilibrium with ambient conditions. Winnowing, if it occurs, will produce a coarsening in the surficial grain size distribution or the natural deposition of mud on the deeper areas of the cap may take place. In addition, if internal deformations are unexpectedly large, mud lumps may form on the surface. If these do appear they should be distinguishable from muds that may happen to be accumulating on the surface by their high density, perhaps by their composition and by coring to search for the presence or absence of the sand cap under the feature.

15. Additional, optional surveys of the cap condition might be done after major storms. A side-scan sonar survey may also be useful to document the condition of the cap. Finally, although dredged sediment deposits are notoriously opaque to acoustic signals, an attempt might be made to see the internal structure of the deposit with seismic reflection equipment in an attempt to see changes in the position of the sand-mud interface. A technique using an ORE, Inc. Model 1032 sub-bottom profiling system and a computerized data acquisition system from Caulfield Engineering (Alberta, Canada) has been useful at the Mud Dump site (Parker and Valente, 1987).

PRELIMINARY MANAGEMENT PLAN

A management decision tree for a borrow pit disposal operation (Figure 1) starts with the assumption that a particular project is suitable for this disposal option, that a disposal buoy is in place and a detailed bathymetric survey of the site is available.

The manger begins by estimating the form of the deposit that would result if the entire project was discharged at the buoy. Such estimates are empirical forecasts based on past experience and, as a result, the estimates will improve as more experience is gained. Some guidelines may be specified now, however, by which initial estimates can be made. Based on the configuration of existing mounds of dredged sediment at open water sites, three general criteria might be considered (Bokuniewicz, et al., 1986).

1. The physical processes involved in the placement of dredged sediment at open-water sites limit the radius of the deposit to less than 250 yards under a wide range of conditions.

2. For mud deposited from a slurry, the side slopes of the resulting deposit are typically less than 2 degrees.

3. For sand or clumps of mud, the side slopes of resulting deposits are typically found to be about 8^{o} even though slopes as steep as about 30^{o} are possible.

BORROW PIT DISPOSAL SITE MANAGEMENT

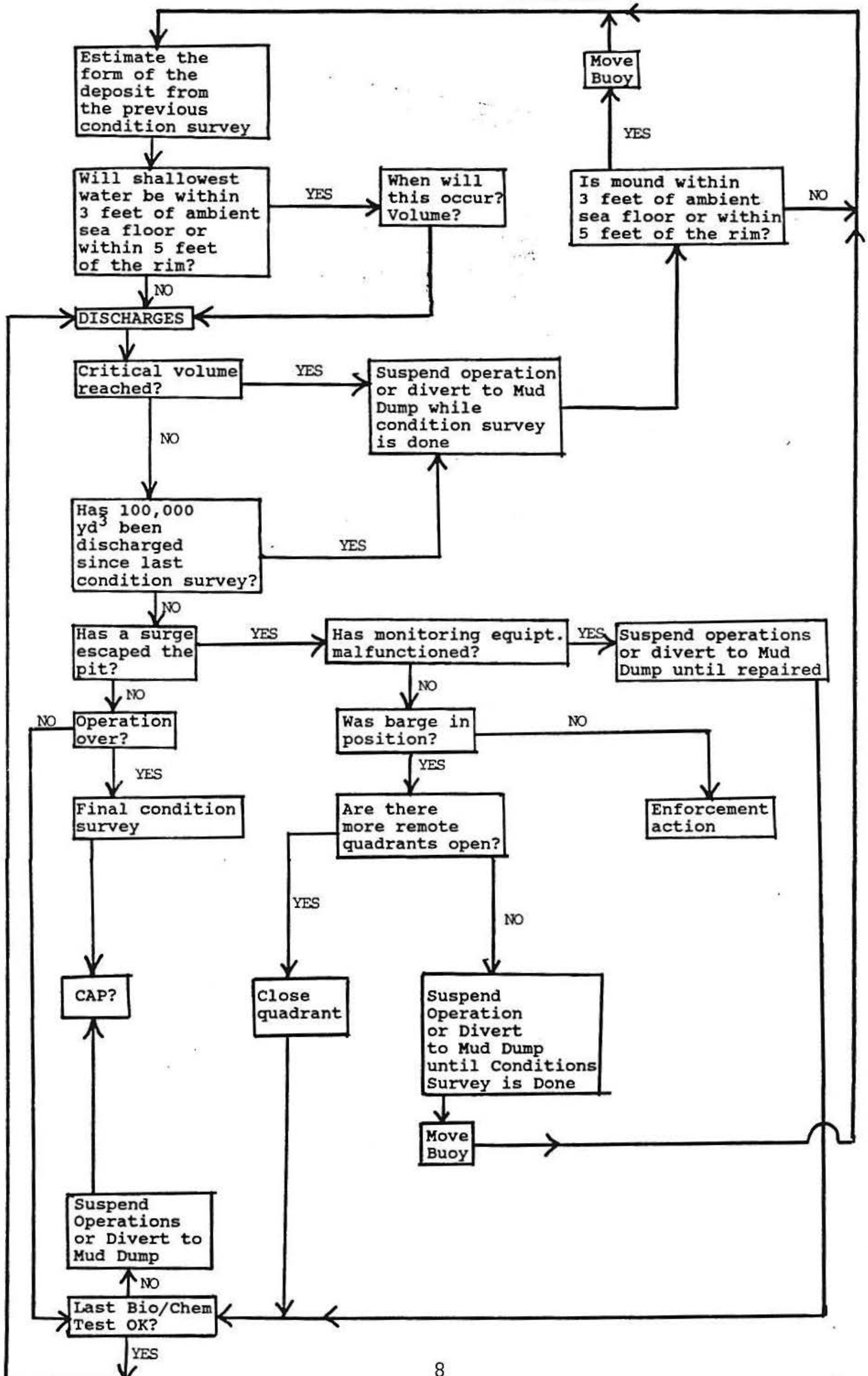

Figure 1

These criteria may be combined to create an envelope of radial profiles which show the up limits to the elevation of mounds of dredged sediment for various volumes (Figure 2). For any particular volume, the radial cross section of the deposit should be expected to lie entirely beneath the appropriate envelope for that deposit, possibly, far below the envelope depending on the grain size and mounding characteristics of the dredged sediment.

The bathymetric critria are two: (a) the apex of the final mound cannot come within 3 feet of the elevation of the sea floor surrounding the pit and (b) the surface of the deposit where it intersects the pit cannot be within 5 feet of the rim. If the specific project is forecast to exceed these limits then the manager estimates what fraction of the project (a critical volume) can be discharged at the buoy's present location. Discharges then are allowed to begin. The on-site inspector reports daily volumes and the manager watches for three events: (a) reaching the critical volume for that discharge location, (b) reaching a cumulative volume of 100,000 cubic yards since the last condition survey and (c) evidence of the escape of the surge from the pit. If (a) or (b) happen, then the disposal operations are suspended (or, if the dredged sediment is suitable, diverted to the Mud Dump) while a partial condition survey is run. The manager checks the condition survey against the bathymetric criteria listed above. If there is still room at that location, the manager revises his or her estimate of how much more material can be discharged before moving the buoy and the operation continues. If the deposit meets either of the bathymetric criteria, the buoy is moved and the process continued at a new location.

If there is evidence that the surge has escaped from the pit then another set of steps are taken. First, the manager must check that the evidence is valid and not due to some malfunction of the monitoring technique. If it is a malfunction, then the operation is suspended (or diverted to the Mud Dump) while the malfunction is corrected. If the equipment is functioning the manager then checks to see if the barge was in a proper position. If it was not, some enforcement action would be taken, for example, the operation might be suspended at least until the operator can insure proper placement. If the barge was in position, however, then that position is too close to the rim of the pit; that quadrant around the disposal buoy could be closed and discharges only permitted on the other sides of the buoy further away from the rim. If the other quadrants have already been closed then operations must be suspended (or diverted to the Mud Dump) a condition survey run, the buoy moved and the process started anew.

Discharges can continue as long as the last results of the biological/chemical monitoring are negative. Statistically significant trends in the monitoring data must be judged to be either acceptable or unacceptable; this is a qualitative judgment to be made by the regulatory agencies on a case-by-case

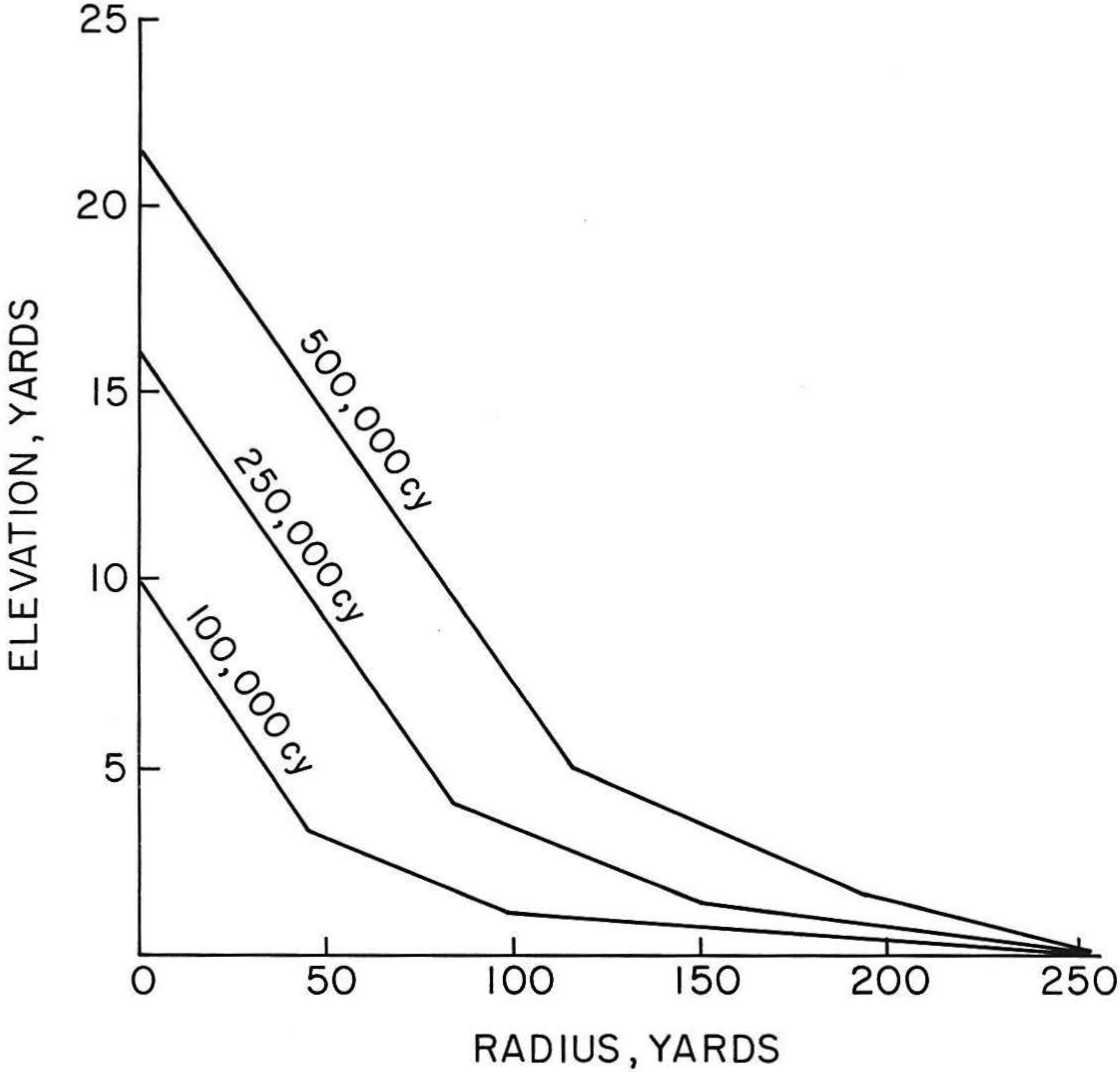
25
20
15
10
5
ELEVATION, YARDS
500,000cy
250,000cy
100,000cy
0
50
100
150
200
250
RADIUS, YARDS

Figure 2

basis. If the results show unacceptable, statistically significant trends, then operations are suspended (or diverted to the Mud Dump) and mitigating action must be initiated, for example, capping.

When the operation is over, a final condition survey is done and the manager decides whether or not a cap should be placed. The next scheduled project might be allowed to be the cap for the last project unless the interval between projects includes a time of benthic recruitment. If it does, a special interim cap might be required depending on the qualify of the last material discharged.

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