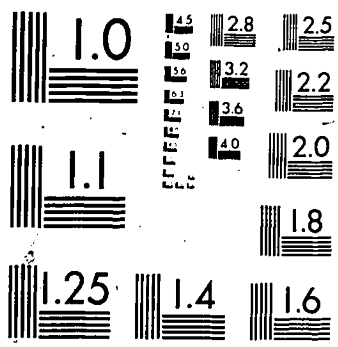

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AUTHOR Koundakjian, Philip
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ABSTRACT

This self-paced course contains reading assignments from a waste stabilization ponds operating manual, supportive text, example problems, and review questions, and a final examination. The course covers calculation of pond surface area, pond volume, organic load, detention time, drawdown, storage capacity, efficiency, and discharge. In addition, it covers the biological processes of a lagoon, chemical additions, typical problems and solutions, and safety hazards. (BB)

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6301 Kirkwood Blvd. S.W.
P.O. Box 2068
Cedar Rapids, Iowa 52406

WASTE STABILIZATION PONDS

Developed by

Philip Koundakjian, Instructor
John Weber, Instructor
Kirkwood Community College
Cedar Rapids, Iowa

for

U.S. Environmental Protection Agency

September 1976

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WASTE STABILIZATION PONDS

A self-paced course of instruction dealing with the operation of Waste Stabilization Ponds.

This pamphlet contains reading assignments, supportive text, example problems, and review questions. Reading assignments Sections A, B, C, etc. are contained in Waste Stabilization Ponds Operating Manual. You should read the assigned materials for each section, read the supportive text in this pamphlet, answer the review questions in this pamphlet, grade your answers, and re-read as necessary to gain an understanding of the problems or questions with which you had difficulty. Answers to the review questions are at the back of this pamphlet. After you complete all assigned readings and questions take the final examination.

You will need a slide projector to view the slides and a pocket calculator would be of some assistance in working the problems if one is available to you.

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Upon completion of this course the student should:

1. Be able to calculate pond surface area.
2. Have a basic understanding of the biological processes of the lagoon.
3. Understand series and parallel flow configuration and relative merits and shortcomings of each.
4. Be able to calculate pond volume.
5. Be able to calculate organic load (lb. BOD/day and lb. BOD/acre/day).
6. Be able to calculate detention time.
7. Be able to calculate drawdown.
8. Be able to calculate storage capacity.
9. Be able to calculate efficiency.
10. Be able to calculate discharge (lb. BOD/day).
11. Have basic understanding of chemical additions.
12. Be able to recognize and document typical problem situations and offer possible solutions.
13. Be aware of hazards of pond operation.
14. Be safety conscious.

STUDENT GUIDE

1. Read: Preface, Section A, Excerpts from "Recommended Standards for Sewage Works", Sketches 1, 2, and 3.

The surface area of lagoon cells is the first calculation to be mastered. Surface area is as the term states, the area of the surface of the lagoon, or the area of the liquid surface that is visible or exposed to the atmosphere. It is generally expressed in acres.

Sketch 1 shows a lagoon that is 260' wide by 850' long. The maximum liquid depth is 5' and the slope of the side walls is 3:1, that is the wall from Point A on Sketch 1 for each 3' horizontal, it rises 1'.

The surface area calculation is:

260' x 850' = 221,000 square feet

One acre contains 43,560 square feet

Therefore, 221,000/43,560 = 5.07 acres

Sketch 2 shows a two-cell lagoon. Each lagoon measures 265' by 370'. The maximum liquid depth is 5' and the slope is 4:1. It is important to calculate each cells surface area. The calculation of the area for <u>each</u> cell will be used in subsequent calculations. Total surface area is the sum of the areas of each cell.

Cell 1 surface area

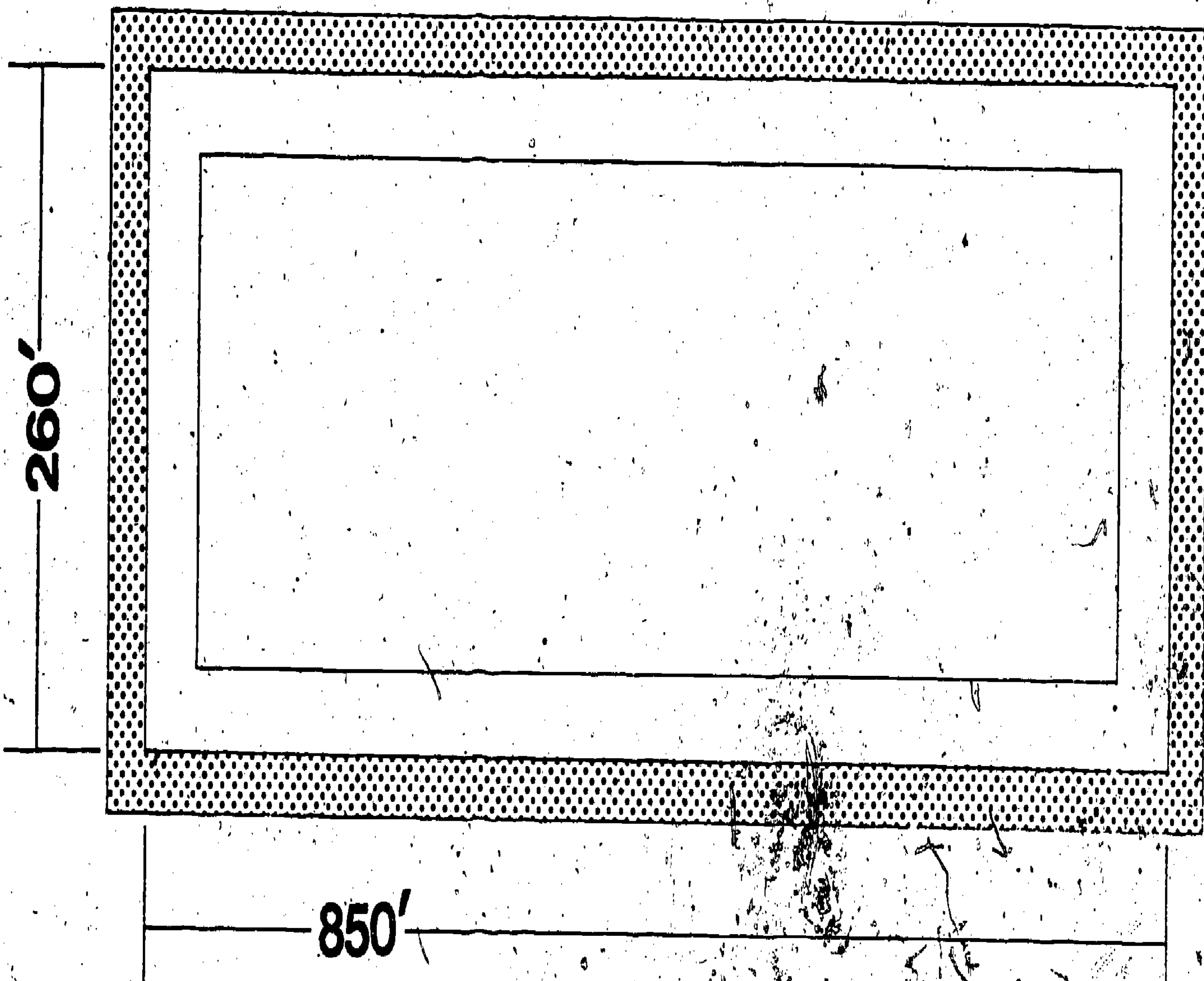
265 x 370 = 98,050 square feet

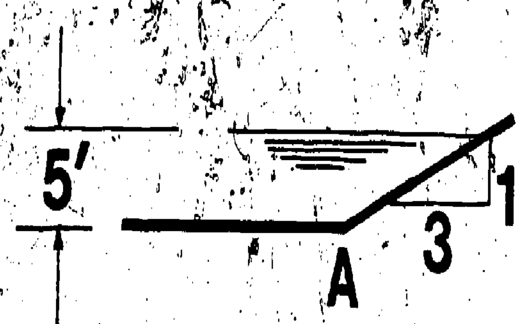
98,050/43,560 = 2.25 acres

Cell 2 has identical dimensions; therefore,

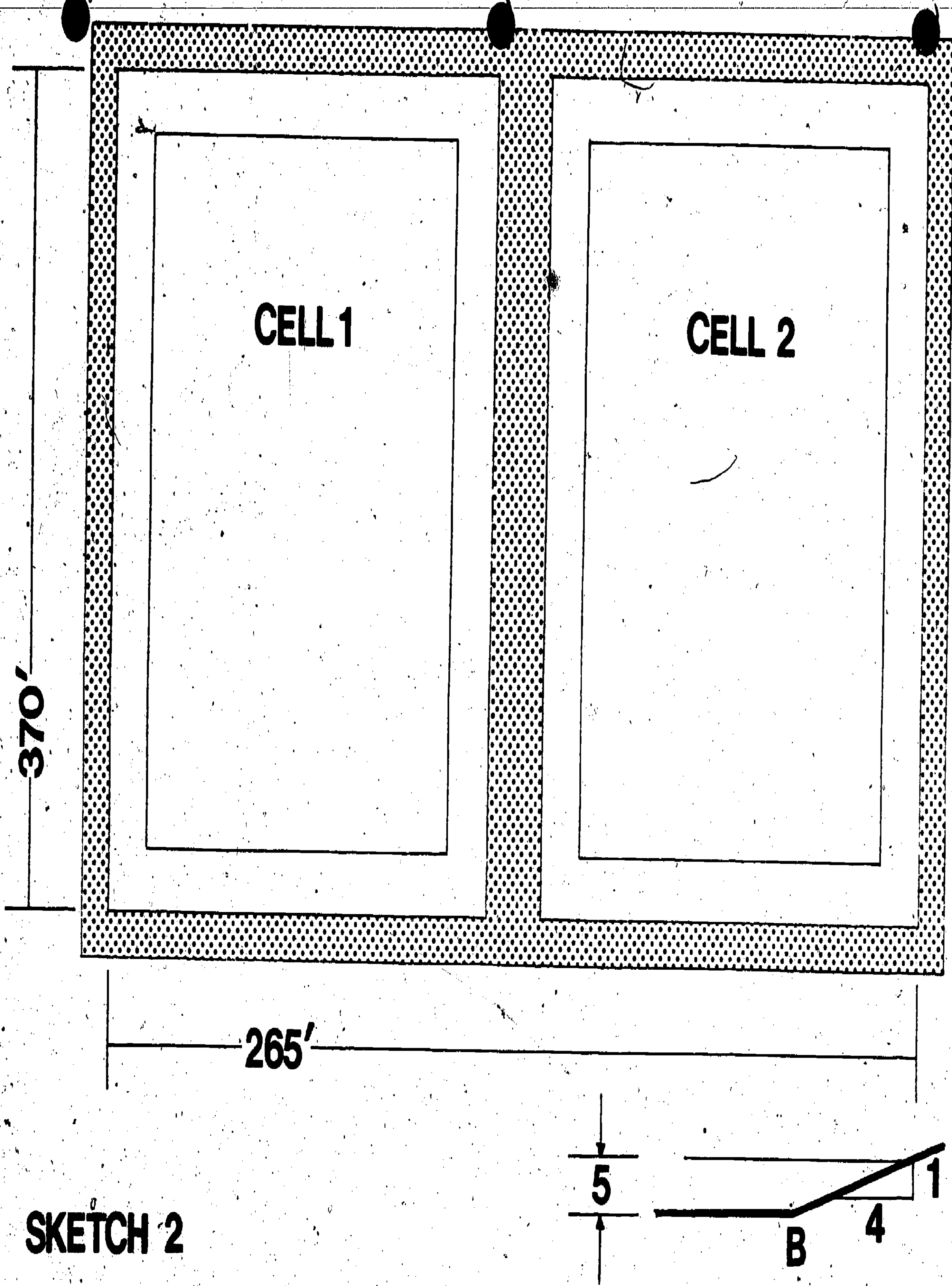
Cell 2 surface area = 2.25 acres

Total surface area = 2.25 + 2.25 = 4.50 acres





SKETCH 1



SKETCH 2

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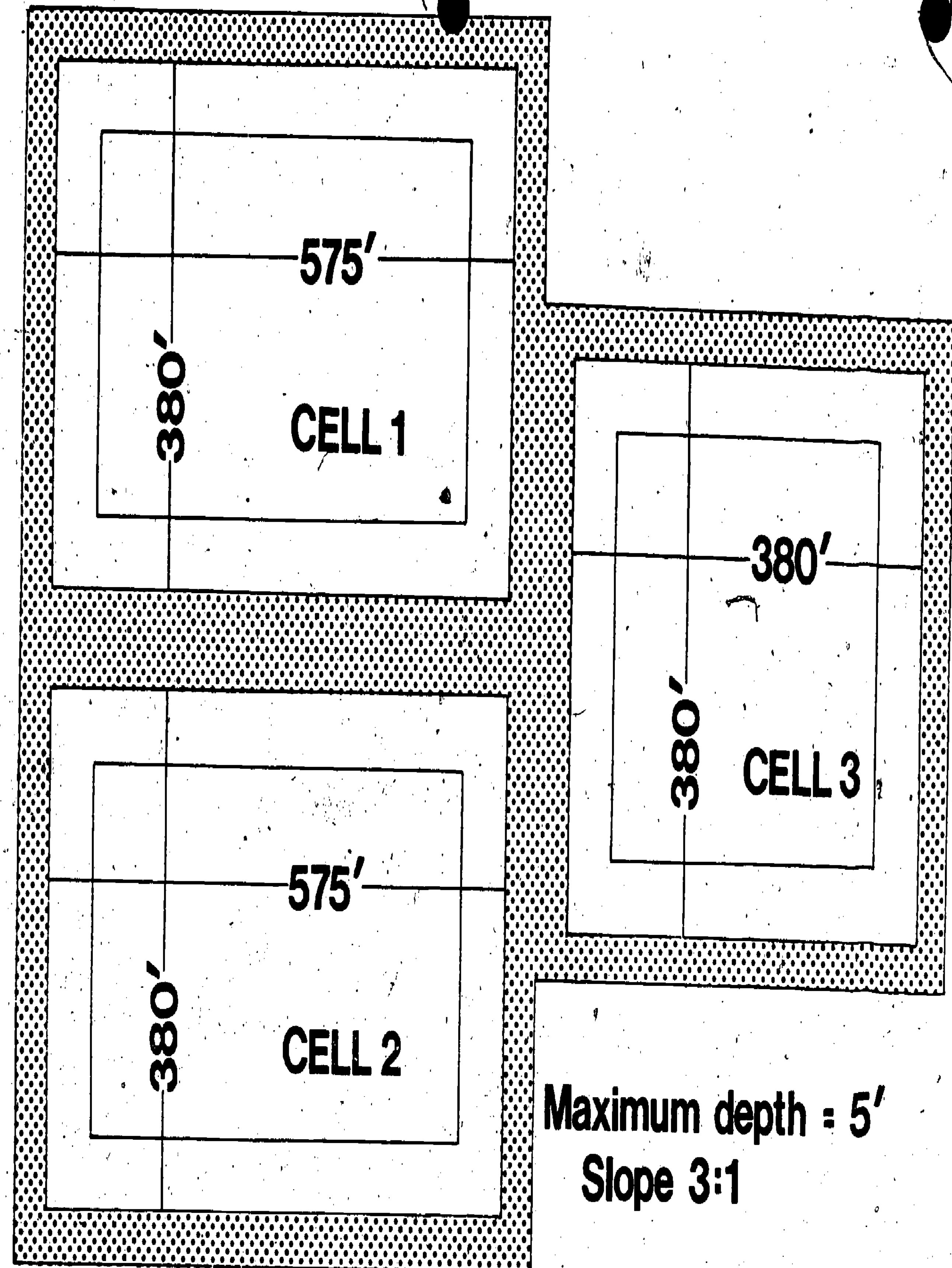

Maximum depth = 5′
Slope 3:1

SKETCH 3

Questions - Section A

1. Generally, the minimum operating depth for a lagoon is _________ feet.

2. The lagoons diagrammed in Sketch 2 have sidewall slopes of 4:1. Then from Point B, as shown on the sketch, the sidewall goes up _________ for every _________ it extends.

3. Using Sketch 3, calculate the surface areas of each cell.

   Cell 1 _________ acres

   Cell 2 _________ acres

   Cell 3 _________ acres

   The total surface area for the three cells is _________ acres.

II. Read: Section B

It is important for the student to gain a basic understanding of "How a Lagoon Works".

Raw sewage flows into a lagoon. If the lagoon has been properly designed, constructed, and operated, effluent, or discharge from the lagoon is no longer raw sewage. It is not magic. It is a result of biological activity and settling.

Section B discusses the "Concepts of Treatment". In this section it is stated that "Certain sewage solids (volatile solids) satisfy the nutritional needs of the microorganism in the stabilization pond." Volatile solids are defined as solids capable of being burned. It should be added that the "burning" is done at a given (or standard) temperature of 550° Centigrade (1,022° Fahrenheit).

This section may have to be read several times by the student. As the section is being studies, remove Figure B 4 and have it in front of you as you read the section.

The first nine pages address the activity in the lagoon. Page B 10 and the remaining pages discuss the Biochemical Oxygen Demand (BOD) test. The test is based on the fact that if you have organisms, food for the organisms, and oxygen - the organisms will "eat" the food. In order for organisms to eat food, they need oxygen. As they eat, they use up the oxygen. So if you take a measured volume of wastewater (it contains food), "seed" it (to assure you have organisms), and aerate it (to assure you have oxygen), you are able to determine the BOD of the sample.

Consider two samples. One has large amount of food, the second very little food. The first could be raw wastewater, the second treated wastewater.

If we take equal sample volumes of each, seed them, and aerate them so each has the identical amounts of oxygen, what would occur? Since the first sample (raw wastewater) has the most food, more oxygen would be consumed in the first sample as the organisms eat the food.

The BOD determination indirectly measures the amount of food in a given sample. The direct measurement is that of how much oxygen is consumed by the organisms "eating the food". The greater the amount of food, the greater the activity, the more oxygen used.

The results of the BOD determination are reported as shown on Page B 10. The lagoon operator doesn't necessarily need to know how to run the BOD test, he does need to understand the results. Computing load to the lagoon will be covered in a later section.

Questions: Section B

1. Organisms found in the bottom sludge layer of the lagoon are termed ________________.

2. Organisms found in the area where at times available oxygen exists and at times it doesn't are termed ________________organisms.

3. The organisms that live in the area where dissolved oxygen is available are termed ________________.

4. A small community's wastewater flow averages 100 gallons per person per day. That means that for each person 750 pounds of water flow into the town's lagoon each day. About how many pounds of solids would you expect from each person are going into the lagoon? ________________.

5. In the aerobic zone of the lagoon the dissolved oxygen level is generally the highest in the ________________ and at its lowest level just before ________________.

6. Algae is beneficial to lagoons because under proper conditions algae produces ________________.

7. If the discharge from a lagoon contains both fecal coliform organisms and pathogenic organisms, which present the greatest threat to public health? ________________.

8. Which organism is considered an "indicator" or is used as a guide to effluent quality? ________________.

9. A lagoon has been operating at 88 percent efficiency. The raw BOD has averaged 185 ppm. What has the final effluent (discharge) BOD been? ________________.

Reading Assignment: Section C

Questions for Section C

1. A pond is being started during the summer. In order to prevent weed growth and odors the pond should be filled as rapidly as possible to the ____________________ foot level.

2. A two pond system is to be started. Would it be better to fill the ponds one at a time, or both at the same time? ____________________.

3. A steadily declining dissolved oxygen level could be an indication of ____________________ or ____________________.

Reading Assignment: Section D

One of the main functions of the lagoon operator is to control liquid depth. A lagoon which is allowed to remain at less than three foot may develop heavy weed growth. If the lagoon is allowed to remain full too long, the operator has no reserve capacity. This requires that the operator have knowledge of his lagoon's capacity and the flow coming into the lagoon. Knowledge of flow includes not only the average flow but variations in flow. For example, if there is an infiltration problem in the sewer system, how much does the flow increase during and after rainfall. Another possibility is seasonal variations in flow. It is the operator's responsibility to document and retain such flow data. Flow data should be displayed graphically. The graph can then include notes which document rainfall, ice cover, dates of drawdown etc. A well maintained graph becomes an excellent tool for the conscientious operator.

Surface area calculation should have now been mastered. The next calculation to be addressed is that of lagoon volume. Page D 2 has an example of the calculation. The three sketches used in Section A will now be used for practice in volume calculations.

Sketch 1: Surface area = 221,000 square feet.

221,000 x 1 = 221,000 cubic feet per foot of depth.

There are approximately 7.5 gallons per cubic foot.

221,000 x 7.5 = 1,657,500 gallons per foot of depth.

1,657,500/12 = 138,125 gallons per inch of depth.

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With this calculation the operator can calculate reserve capacity. Assume that the flow into this lagoon is 85,000 gallons per day. If the depth of the lagoon is 4 feet 3 inches, how many days reserve capacity remain in the lagoon? (We will assume no losses.)

We have calculated the number of gallons per inch in the lagoon. The maximum depth for this lagoon is 5 feet. So 9 inches of lagoon remain to be filled.

9 inches x 138,125 gallons per inch = 1,243,125 gallons.

1,243,125/85,000 = 14.6 days

We can now also calculate drawdown (discharge) rates. Many lagoons are limited in their allowed rate of drawdown. They are not allowed simply to open a valve and discharge as fast as the flow will come out. Assume that the maximum allowable discharge rate is 700,000 gallons per day. The calculation procedure is similar. How many inches will the lagoon go down if 700,000 gallons are discharged?

700,000 gal./138,125 gal. per inch = 5 inches

But, this is a one cell lagoon. The lagoon is receiving 80,000 gallons per day. We have to take this into account.

[illegible]000 /138,125 = 0.6 inches

You must remember then that if figuring drawdown you have to take into account the volume of flow going into the lagoon. In multiple cell systems, it is generally not included. One usually tries not to have any flow going into a cell that is being drawn down.

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There is one other calculation the operator should routinely make. That is to check the "per capita flow" coming into the lagoon. This is important even if the operator is fortunate enough to have some type of automatic flow recording device. Why? Automatic recording flow devices can be wrong.
A typical lagoon might have a flow of 100 gallons per capita per day. This may range from 50 to 200 dependent on the community (such things as industry, high infiltration may make this number vary.)

An example: Assume a community of 1,100 people has a lagoon. The flow into the lagoon averages 80,000 gallons per day. What is the per capita flow?

80,000 gal. per day/1,100 people (capita) =
72.7 gallons per capita per day

Questions Section D

1. Most lagoons do not require total work day attention. The manual suggests that there are seven general conditions which could be checked daily. They are:

   1. ____
   2. ____
   3. ____
   4. ____
   5. ____
   6. ____
   7. ____

2. If a lagoon has a five foot maximum depth capability it is desirable to operate the lagoon at between ____ and ____ feet to inhibit weed growth and still have some reserve capacity.

3. Odors can sometimes be an indicator of ____ PH in a lagoon. (High or low).

4. Lagoons carrying maximum quantities of dissolved oxygen may have a PH ____ 7.0 (above or below).

5. A community of 650 people has an average wastewater flow of 72,000 gallons per day into a lagoon. What is the per capita flow? ____.

6. Using Sketch 3 calculate the capacity per inch of depth for each cell.

   Cell one ____ gal. per inch.
   Cell two ____ gal. per inch.
   Cell three ____ gal. per inch.

7. Cell three from the previous problem has 5 feet of liquid in it. There will be no flow coming into the cell. Three feet of liquid is to be discharged. The maximum discharge rate allowed is 900,000 gallons per day. How many days will it take to accomplish the drawdown?

   ____.

8. The raw wastewater flow into the same three cell lagoon system is 130,000 gallons per day. Cell two is at the 4 foot liquid level. The raw flow is being directed only into cell two. How many days will it be until the liquid level is 5 foot? ____.

9. Aerobic organisms are especially sensitive to ____ PH conditions. (High or low).

10. An industry in a small community uses sulfuric acid in its manufacturing process. A tank car load was accidentally dumped into their sewer. The lagoon operator could expect that the PH will be ______________ 7.0 in his lagoon. (Above or below).

20. It is early in August in a midwestern state. The weather has been hot and windy. A community has a one-cell lagoon with a surface area of 5 acres. The average daily flow into the lagoon is 50,000 gallons per day. There is a weather station in this community. The operator was told that evaporation losses have been averaging 1/4 inch per day. If the evaporation loss is true, will the level of the pond go up or down? ________________. What is the evaporation loss from this lagoon using 1/4 inch per day loss?

________________ gallons per day.

Reading Assignment: Section E

Read the assigned section. View the slides. The slides contain some problem situations and other typical lagoon installations. As the problem situations are viewed, place yourself in the role of the operator. What can you do to correct or attempt to correct the situation.

There are an additional six pages appended, "Oxidation Lagoon Problems", which contain problems and probable solutions.

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Questions - Section E

1. Would you expect weeds to give the operator more trouble in the middle of the lagoon or at the edges? ________________.

2. List six conditions which could cause low dissolved oxygen levels in a lagoon.

1. ______________________ 4. ______________________
2. ______________________ 5. ______________________
3. ______________________ 6. ______________________

3. If algae is growing in a lagoon, it should immediately be killed (yes or no) ________________.

Reading Assignment: Section F

Special emphasis is to be placed on the last paragraph on Page F 4. There are times where chemical additions are appropriate to a lagoon system. However, they should never be added indiscriminately. It is also appropriate to always notify the regulatory agency to whom you are responsible when chemicals are to be added to a lagoon.

Note Figure F 5 as there will be later discussion of series and parallel operation.

Questions - Section F

1. A lagoon has a surface area of 8 acres. Sodium nitrate is to be added to alleviate a low dissolved oxygen condition. How many pounds will the operator add? ____________________.

2. A 4.5 acre lagoon has an excessive amount of algae. Copper sulfate is to be added. How many pounds should be added to this lagoon? ____________________.

Reading Assignment: Section G

The lagoon operator generally has an "Operations and Maintenance Manual" that is designed for the lagoon system at which he's working. It will contain preventive maintenance, manufacturers data, operating instructions etc. However, this section would be an excellent addition to supplement the manual.

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Questions - Section G

1. Lift station pumps are usually ________________ pumps.

2. When flow is turned into an empty pump, the air in the pump will be trapped against the discharge check valve, creating a condition known as ________________.

3. "Bleeding" air from a pump is done to correct a condition known as ________________.

4. What are three symptons of a bearing approaching failure. ________________, ________________, ________________.

5. Name five methods of monitoring wet well level.

   1. ________________
   2. ________________
   3. ________________
   4. ________________
   5. ________________

6. Gate valves generally require ________________ to open while plug valves require ________________ (several turns or one-quarter turn.)

7. While in the closed position, ________________ valves are most prone to "freezing" (gate or plug).

Reading Assignment: Sections H and I

Care must be exercised in collecting samples. It is the sample from which analyses are run. These results are then reported on required reports and used to evaluate lagoon performance.

There are two types of samples - grab and composite.

Grab samples are simply a sample taken and then analyzed. The operator should note from where the sample was taken, the time of day, and the date.

Example: Raw wastewater   Distribution Box 1   2:00 p.m.   8/13/76

Composite samples are really a collection of grab samples that are collected over a period of time and at measured volumes.

Discharge permits usually state what type of samples are required for given analyses. The operator should check with the appropriate regulatory agency if he has any questions as to what his sampling requirements are.

Section I addresses "Evaluating Pond Performance". Surface area and volume calculations should have been mastered by this time. Organic loading and detention time calculations now are to be addressed.

The detention time calculation requires only the total volume of the lagoon and the average daily flow. Correcting the lagoon dimensions for the slope gives a more exact answer, but in reality the slope correction can be ignored if you realize that the true volume is somewhat less than the volume calculated if slope correction is not made.

Return to Sketch 1. If the lagoon is operating at 5 feet and the average flow into the lagoon is 70,000 gallons per day, what is the average detention time?

260 x 850 x 5 = 1,105,000 cubic feet.

1,105,000 x 7.5 = 8,287,500 gallons.

8,287,500/70,000 = 118 days.

The detention time if we make slope corrections:

260 - 15 = 245 feet (See Page 123)

850 - 15 = 835 feet

245 x 835 x 5 = 1,022,875 cubic feet

1,022,875 x 7.5 = 7,671,562 gallons

7,671,562/70,000 = 110 days

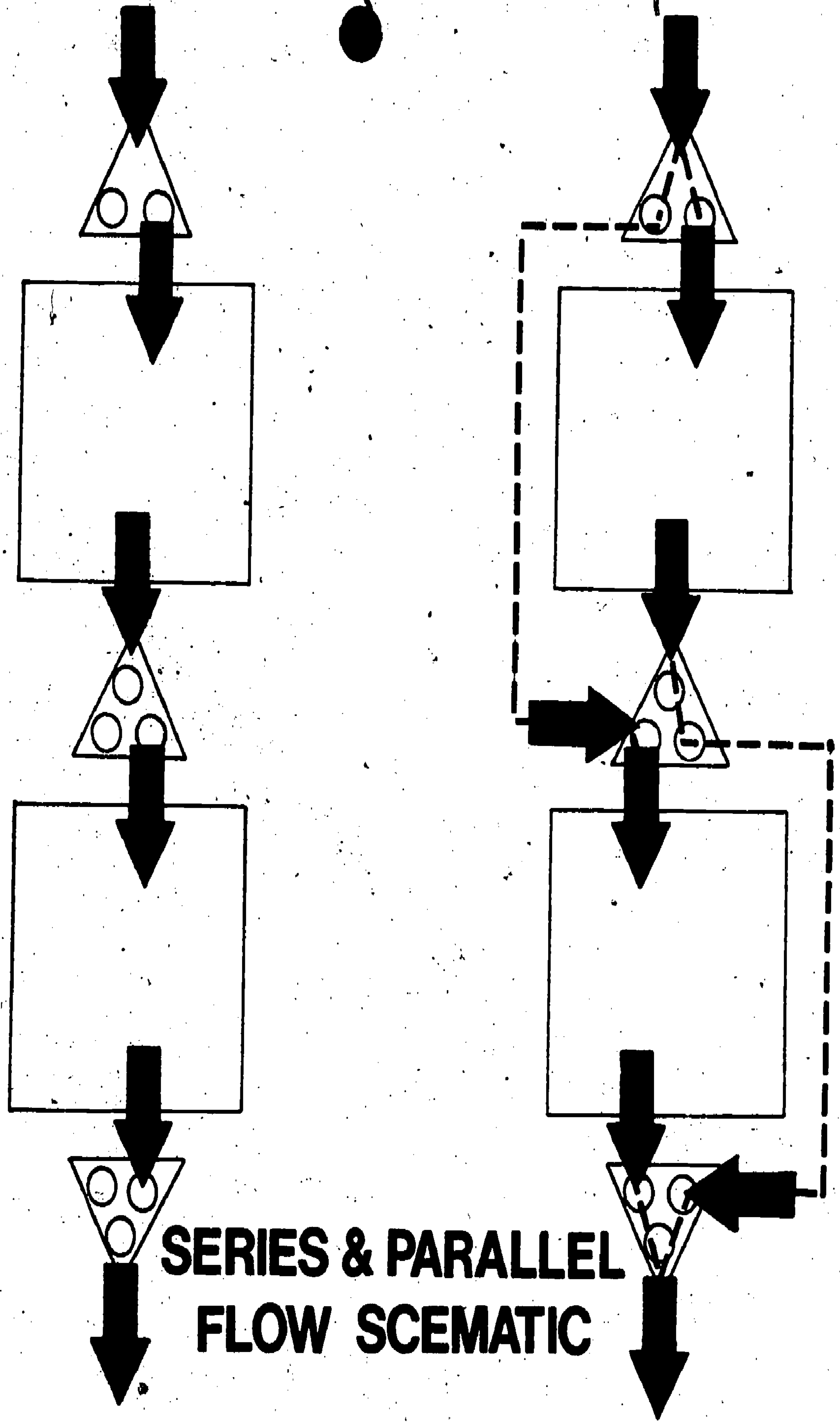
The difference of 8 days only suggests a need for the operator to be consistent. If slope correction is used, always use it.

The next calculation is for organic loading. Section A stated that BOD loading to a single cell lagoon should be 35 pounds BOD per acre per day. The lagoon from Sketch 1 has an average daily flow of 70,000 gallons per day. The raw wastewater BOD is 250 ppm. What is the organic load? First look at the example problem on the bottom of Page 15. Notice that the flow must be expressed in million gallons per day. The solution is:

0.070 x 8.34 x 250 = 146 pounds BOD per day.

146/5 = 29 pounds BOD per acre per day.

More and more lagoon systems are being designed with two or more cells. There remains one important topic to be addressed. That is "Mode of Operation" (series or parallel operation). Sketch 4 shows the flow schematic for a two-cell lagoon. In series operation all flow enters the first cell and then into the second cell. In parallel operation the flow is distributed between the two



SERIES & PARALLEL
FLOW SCEMATIC

SKETCH 4

ERIC

cells. How does one determine if the system should be operated in series or in parallel? In fact there are circumstances when series operation is more appropriate, circumstances when parallel operation is more appropriate.

Using the lagoon system diagrammed in Sketch 2, consider the following:

	Cell 1	Cell 2	Total
Surface Area (acres)	2.25	2.25	4.50
Volume (gallons)	3,676,875	3,676,875	7,353,750

Average daily raw wastewater flow = 60,000 gal. per day

Average raw wastewater BOD = 280 ppm (mg/l)

First calculate the raw wastewater load (pounds BOD per day).

$0.06 \times 8.34 \times 280 = 140$ pounds BOD per day.

If the lagoons are operated in series, what is the organic load on the first cell?

$140/2.25 = 62$ pounds BOD per acre per day.

Now recall that during the summer months treatment accomplished is at a maximum due to more hours of sunlight. This results in more algae growth. This results in higher dissolved oxygen levels. This results in more oxygen available for organisms to utilize as they "eat". This means that a single cell can be loaded while the second cell can be allowed to be isolated. The second cell is tested periodically until it can be drawn down. After drawdown, the second cell is then fed raw wastewater and the first cell is then isolated and tested until it is suitable for discharge.

Now during the winter months, biological activity is reduced. But consider the loading if the operator operates the lagoons in parallel.

0.06 x 8.34 x 280 = 140 pounds BOD per acre per day.

140/4.5 = 31 pounds BOD per acre per day.

The raw load is fed equally to both cells resulting in a reduction in the organic load to each cell. Through the winter months this parallel mode could prevent organic overload which could result in an odor problem, for example. Then when the spring thaw occurs, one cell can be closed and allowed to stand with no additional "food" being added until it's suitable for discharge. During this time the other cell takes all of the waste flow. The operator must be able to determine his reserve capacity. He then will know how long the isolated cell can be allowed to stand before he "runs out of space".

Questions - Sections H and I

1. Samples taken from a lagoon will give the most information if taken at ____________ and ____________ with separate analyses run on the two samples.

2. Samples should be stored in ____________ containers.

3. List the "six vital steps" to laboratory and plant control.

   1. ____________ 4. ____________
   2. ____________ 5. ____________
   3. ____________ 6. ____________

4. A lagoon's raw waste has a BOD of 175 mg/l, the average daily flow is 36,000 gallons per day. How many pounds per day of BOD are entering the lagoon? ____________

5. Given the following two-cell lagoon system each cell is 300 feet by 400 feet. Slope of sidewalls is 4:1. The depth of each cell is 5 feet maximum. Average daily flow is 31,000 gal. per day. Average raw BOD is 212 mg/l.

   Calculate the BOD load on the first cell in series operation (pounds BOD per acre per day). ____________.

   Calculate the BOD load on each cell in parallel operation (pounds BOD per acre per day). ____________.

Reading Assignment: Section J

Many of the topics in this section have been addressed in previous sections. The fact remains that the good lagoon operator keeps orderly records, graphs data, and uses his records to assist him in operating his lagoon system.

Reading Assignment: Excerpts from the "Minnesota Pollution Control Authority Lagoon Manual", Pages MPCA - 107 through MPCA - 118.

There are no 12 pages in this manual of greater importance to the lagoon operator. These pages should be read and re-read. If you become a lagoon operator these 12 pages should be read at regular intervals. The operator should inspect his system and add appropriate safety instructions to this list.

Questions - Pages MPCA - 107 through MPCA - 118.

1. Read the pages again.

This concludes the assigned readings. There are some additional materials included for you to read and refer to in the future if you become a lagoon operator.

EXCERPTS FROM "RECOMMENDED STANDARDS FOR SEWAGE WORKS"
(To be used with Section A)

ERIC

CHAPTER 90

WASTE STABILIZATION PONDS (Lagoons)

91. Supplement To Engineer's Report

The engineer's report shall contain pertinent information on location, geology, soil conditions, area for expansion, and any other factors that will affect the feasibility and acceptability of the proposed treatment.

The following information must be submitted in addition to that required in Section 11, engineer's report.

91.1 Supplementary Field Survey Data

91.11 The location and direction of all residences, commercial development, and water supplies within 1/2 mile of the proposed pond.

91.12 Soil borings to determine surface and subsurface soil characteristics of the immediate area and their effect on the construction and operation of a pond located on the site.

91.13 Data demonstrating anticipated percolation rates at the elevation of the proposed pond bottom.

91.14 A description, including maps showing elevations and contours of the site and adjacent area suitable for expansion.

91.15 Sulfate content of the basic water supply.

92. Basis Of Design

92.1 Area And Loadings

One acre of water surface should be provided for each 100 design population of population equivalent. In terms of BOD, a loading of 0.5 pounds per day per 1,000 square feet should not be exceeded. Higher design loadings will be judged after review of material contained in the engineer's report and after a field investigation of the proposed site by the reviewing authority.

Due consideration will be given to possible future municipal expansion and/or additional sources of wastes when the original land acquisition is made. Suitable land should be available at the site for increasing the size of the original construction.

Substantially higher loadings may be approved for the more southerly states and for installations requiring summer operation only. In cold climates, where substantial ice cover may be expected for an extended period, it may be desirable to operate the facility to completely retain wintertime flows.

92.2 Industrial Wastes

Due consideration will be given to the type and effects of industrial wastes on the treatment process.

92.3 Multiple Units

Multiple cells designed to permit both series and parallel operation are recommended for all except small installations (6 acres or less). This flexibility is desirable when loadings are light or when a community is installing a new sewer system, since in the period preceding substantial connections, the entire discharge can be put into a single cell, thus facilitating the maintenance of satisfactory water levels. In addition, when a low algae content in the effluent is desired, the cells may be advantageously operated in parallel during fall, winter, and spring when algae development is less intensive and in series during the summer months. Series operation is also beneficial where a high level of BOD or coliform removal is important.

Where a greater degree of treatment is necessary or desirable, 1 or more cells in each series may be added to the primary cell. In series operation, the primary cell shall have a surface area equal to that set forth in Section 92.1.

92.4 Pretreatment

When ponds are used to provide additional treatment for effluents from existing or new primary or secondary sewage treatment works, the reviewing authority will, upon request, establish BOD loadings for the pond after due consideration of the efficiencies of the preceding treatment units.

92.5 Pond Shape

The shape of all cells should be such that there are no narrow or elongated portions. Round, square, or rectangular ponds with a length not exceeding 3 times the width are considered most desirable. No islands, peninsulas, or coves should be permitted. Dikes should be rounded at corners to minimize accumulations of floating materials.

93. Location

93.1 Distance From Habitation

A pond site should be as far as practicable from habitation or any area which may be built up within a reasonable future period.

93.2 Prevailing Winds

If practicable, ponds should be located so that local prevailing winds will be in the direction of uninhabited areas. Preference should be given sites which will permit an unobstructed wind sweep across the ponds, especially in the direction of the local prevailing winds.

93.3 Surface Runoff

Location of ponds in watersheds receiving significant amounts of runoff water is discouraged unless adequate provisions are made to divert storm water around the ponds and otherwise protect pond embankments.

93.4 Ground Water Pollution

Proximity of ponds to water supplies and other facilities subject to contamination and location in areas of porous soils and fissured rock formations should be critically evaluated to avoid creation of health hazards or other undesirable conditions. The possibility of chemical pollution may merit appropriate consideration.

94. Pond Construction Details

94.1 Embankments And Dikes

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94.11 Material

Embankments and dikes shall be constructed of relatively impervious materials and compacted sufficiently to form a stable structure. Vegetation should be removed from the area upon which the embankment is to be placed.

94.12 Top Width

The minimum embankment top width should be 8 feet to permit access of maintenance vehicles. Lesser top widths will be considered for very small installations.

94.13 Maximum Slopes

Embankment slopes should not be steeper than:

94.131 Inner

3 horizontal to 1 vertical.

94.132 Outer

3 horizontal to 1 vertical.

94.14 Minimum Slopes

Embankment slopes should not be flatter than:

94.141 Inner

4 horizontal to 1 vertical. Flatter slopes are sometimes specified for larger installations because of wave action but have the disadvantage of added shallow areas conducive to emergent vegetation.

94.142 Outer

Not applicable, except significant volumes of surface water should not enter the ponds.

94.15 Freeboard

Minimum freeboard shall be 3 feet except for very small installations.

94.16 Minimum Depth

The minimum normal liquid depth should be 2 feet.

94.17 Maximum Depth

Maximum normal liquid depth should be 5 feet.

94.18 Seeding

Embankments shall be seeded from the outside toe to 1 foot above the high water line on the dikes, measured on the slope. Perennial type, low growing, spreading grasses that withstand erosion and can be kept mowed are most satisfactory for seeding of embankments. In general, alfalfa and other long-rooted crops should not be used in seeding, since the roots of this type plant are apt to impair the water holding efficiency of the dikes. The County Agricultural Extension Agent can usually advise as to hardy, locally suited permanent grasses which would be satisfactory for embankment seeding. Additional protection for embankments (riprap) may be necessary where the dikes are subject to erosion due to severe flooding of an adjacent watercourse or severe wave action.

94.19 Vegetation Control

A method shall be specified which will prevent vegetation growth over the bottom of the lagoon and up to 1 foot above the water line on the dikes.

94.2 Pond Bottom

94.21 Uniformity

The pond bottom should be as level as possible at all points. Finished elevations should not be more than 3 inches from the average elevation of the bottom. Shallow or feathering fringe areas usually result in locally unsatisfactory conditions.

94.22 Vegetation

The bottom shall be cleared of vegetation and debris. Organic material thus removed shall not be used in the dike core construction. However, suitable topsoil relatively free of debris may be used as cover material on the outer slopes of the embankment.

ERIC

94.23 Soil Formation

The soil formation or structure of the bottom should be relatively tight to avoid excessive liquid loss due to percolation or seepage. Soil borings and tests to determine the characteristics of surface soil and subsoil shall be made a part of preliminary surveys to select pond sites. Gravel and limestone areas must be avoided.

94.24 Percolation

The ability to maintain a satisfactory water level in the ponds is one of the most important aspects of design. Removal of porous topsoil and proper compaction of subsoil improve the waterholding characteristics of the bottom. Removal of porous areas, as gravel or sandy pockets, and replacement with well-compacted clay or other suitable material may be indicated. Where excessive percolation is anticipated, sealing of the bottom with a clay blanket, bentonite, or other sealing material should be given consideration.

94.3 Influent Lines

94.31 Material

Any generally accepted material for underground sewer construction will be given consideration for the influent line to the pond. The material selected should be adapted to local conditions. Special consideration must be given to the character of the wastes, possibility of septicity, exceptionally heavy external loadings, abrasion, the necessity of reducing the number of joints, soft foundations, and similar problems. Surcharging of the sewer upstream from the inlet manhole is not permitted.

94.32 Manholes

A manhole shall be installed at the terminus of the outfall line or the force main and shall be located as close to the dike as topography permits and its invert should be at least 6 inches above the maximum operating level of the pond to provide sufficient hydraulic head without surcharging the manhole.

ERIC

94.33 Influent Lines

Influent lines should be located along the bottom of the pond so that the top of the pipe is just below the average elevation of the pond bottom. This line can be placed at zero grade. The use of an exposed dike to carry the influent line to the discharge points is prohibited, as such a structure will impede circulation.

94.34 Point Of Discharge

The influent line to a single celled pond should be essentially center discharging. Each cell of a multiple celled pond operated in parallel shall have its own near center inlet but this does not apply to those cells following the primary cell when series operation alone is used. Influent lines or interconnecting piping to secondary cells of multiple celled ponds operated in series may consist of pipes through the separating dikes. (Section 94.43) Influent lines to rectangular ponds should terminate at approximately the third point farthest from the outlet structure. Influent and effluent piping should be located to minimize short-circuiting within the pond.

94.35 Inlets

The inlet line shall discharge horizontally into a shallow, saucer-shaped depression which should extend below the pond bottom not more than the diameter of the influent pipe plus 1 foot.

94.36 Discharge Apron

The end of the discharge line should rest on a suitable concrete apron with a minimum size of 2 feet square.

94.4 Overflow Structures And Interconnecting Piping

94.41 Material

Interconnecting piping and overflows should be of cast iron pipe or corrugated metal pipe of ample size.

94.42 Overflow Structure

Overflow structures should consist of a manhole or box equipped with multiple-valved pond drawoff lines or an adjustable overflow device so that the liquid level of the pond can be adjusted to permit operation at depths of 2 to 5 feet. The lowest of the drawoff lines to such structure should be 12 inches off the bottom to control eroding velocities and avoid pickup of bottom deposits. The overflow from the pond during ice-free periods should be taken near, but below, the water surface to release the best effluent and insure retention of floating solids. The structure should also have provisions for draining the ponds. A locking device should be provided to prevent unauthorized access to the level control facilities. When possible, the outlet structure should be located on the windward side to prevent short-circuiting. Consideration must be given in the design of all structures to protect against freezing or ice damage under winter conditions.

94.43 Interconnecting Piping

Interconnecting piping for multiple unit installations operated in series should be valved or provided with other arrangements to regulate flow between structures and permit flexible depth control. The interconnecting pipe to the secondary cell should discharge horizontally near the lagoon bottom to minimize need for erosion control measures and should be located as near the dividing dike as construction permits.

95. Miscellaneous

95.1 Fencing

The pond area shall be enclosed with a suitable fence to preclude livestock and discourage trespassing. A vehicle access gate of sufficient width to accommodate mowing equipment should be provided. All access gates should be provided with locks.

95.2 Warning Signs

Appropriate signs should be provided along the fence around the pond to designate the nature of the facility and advise against trespassing.

95.3 Flow Measurement

Provisions for flow measurement shall be provided on the inlet and outlet.

95.4 Liquid Depth Operation

Optimum liquid depth is influenced to some extent by lagoon area since circulation in larger installations permits greater liquid depth. The basic plan of operation may also influence depth. Facilities to permit operation at selected depths between 2 and 5 feet are recommended for operational flexibility. Where winter operation is desirable, the operating level can be lowered before ice formation and gradually increased to 5 feet by the retention of winter flows. In the spring, the level can be lowered to any desired depth at the time surface runoff and dilution water are generally at a maximum. Shallow operation can be maintained during the spring with generally increased depths to discourage emergent vegetation. In the fall, the levels can be lowered and again be ready for retention of winter storage.

95.5 Laboratory Equipment

See Section 46.4.

SLIDE ONE	This slide shows what could easily result if a lagoon site were ignored. Note the bad situations: 1. Livestock drinking the wastewater. 2. Fences down. 3. Sidewall slopes deteriorated. 4. Mosquitoes. 5. Floating sludge. 6. Weed growth.
SLIDE TWO	A close-up view of the bottom of a clay-lined lagoon. The clay was allowed to dry before the lagoon was filled. The potential for severe leakage exists if this "drying" occurs after a clay-lined pond is constructed.
SLIDE THREE	A typical "control" structure.
SLIDE FOUR	Looking into one type of control structure. The depth of the lagoon is controlled by the number of "gates" in place.
SLIDE FIVE	Another rectangular gate control structure.
SLIDE SIX	Note the shape of this gate.
SLIDE SEVEN	The structure in which the previous gate is used.
SLIDE EIGHT	The gate in place.
SLIDE NINE	Note the vee notch in this structure.
SLIDE TEN	This pond is covered with duckweed. What should the operator do? (Page E-1)

ERIC

SLIDE ELEVEN

This floating mat should also be removed.

SLIDE TWELVE

This lagoon has been lowered to about the one foot level. What problem can the operator anticipate?

SLIDE THIRTEEN

The depth gauge in the previous lagoon-the operator can make little use of this gauge.

SLIDE FOURTEEN

Compare this gauge to the previous slide. Note how easily it can be read.

SLIDE FIFTEEN

A depth gauge similar to the previous one. The gauge is graduated in feet and tenths of feet, not in inches. Riprap has been placed on the downwind slope. The weeds have been allowed to grow uncontrolled; however.

SLIDE SIXTEEN

Some lagoon operators are fortunate enough to have recording devices in addition to depth gauges. This is a one-week circular chart which has recorded the first three days of flow for the week. It is not particularly important that you cannot read the rate of flow. What is important is the red line which the meter is tracing. Notice the flow has been nearly constant for the three days. Very few communities have waste flows this constant. In fact, the float which was recording this flow was found to be stuck. Just because the meter is tracing a flow does not mean the meter is accurate. The float should be checked regularly.

SLIDE SEVENTEEN	Trails of this type are a tell-tale sign that rodents may be a problem.
SLIDE EIGHTEEN	Holes in the slopes of the lagoon are another trouble sign. Notice the corn leaf. It wasn't blown there.
SLIDE NINETEEN	Another hole in the side slope.
SLIDE TWENTY	When holes are burrowed at the water line, wastewater may be drained from the lagoon.
SLIDE TWENTY-ONE	Emergent weed growth and a muskrat are two problems in this lagoon. A passing muskrat is no great problem by himself. The problem is real when the slopes become criss-crossed with burrows.
SLIDE TWENTY-TWO	This at first glance appears to be a lagoon in good shape.
SLIDE TWENTY-THREE	A closer look reveals a severe erosion problem. This lagoon had been constructed with a one foot layer of clay to "seal" the bottom and slides. The seal is no longer intact.
SLIDE TWENTY-FOUR	These slopes have not been properly maintained. This type deterioration lends to mosquito infestation.
SLIDE TWENTY-FIVE	The operator is confronted with a pond that has been overfilled. Possibly he wasn't able to calculate reserve capacity.

SLIDE TWENTY-SIX — This type of riprap is not advisable. Weed control is extremely difficult and mosquitoes could be a problem.

SLIDE TWENTY-SEVEN — This type of riprap is excellent to prevent erosion and excessive growth on the slopes.

ERIC

OXIDATION LAGOON - PROBLEM 1

ODORS

A. SPRING TURNOVER

1. CAUSE

   A. INEVITABLE. IF POND HAS BEEN ICE COVERED, IT HAS TURNED ANAEROBIC.

   B. WILL BE OF SHORT DURATION (3 - 30 DAYS).

2. CORRECTION

   A. IF NO PROBLEMS ARE CREATED, TAKE NO ACTION.

   B. ADD SUPPLEMENTAL AIR - SODIUM NITRATE, MECHANICAL OR DIFFUSED AIR. (CAN BE DONE FROM THE BACK OF A MOTORBOAT.)
   SODIUM NITRATE 100#/AC FOR 3 DAYS, THEN
   50#/AC FOR 7 DAYS

B. EXTENDED CLOUDY WEATHER - NOT TOO COMMON A PROBLEM

1. CORRECTION

   A. NO ACTION IF PROBLEMS AREN'T CREATED - IT WILL TAKE CARE OF ITSELF.

   B. ADD SUPPLEMENTAL AIR - SODIUM NITRATE, MECHANICAL OR DIFFUSED AIR.

   C. USE MASKING AGENT

C. OVERLOAD OR DISCHARGE OF TOXIC WASTES

1. CAUSE

   A. INDUSTRIAL ACCIDENT, SEASONAL LOAD, PROCESS CHANGE. THIS IS THE MOST COMMON SOURCE OF ODOR PROBLEMS.

2. EFFECT

   A. COLOR CHANGE USUALLY TO A DULL GREEN, GRAY OR BLACK.

3. CORRECTION

A. FIND AND ELIMINATE SOURCE OF OVERLOAD

B. ACTIVATE EMERGENCY PLAN

C. ADD SUPPLEMENTAL AIR - SODIUM NITRATE, DIFFUSED OR MECHANICAL AERATION.

D. RECIRCULATION MAY HELP.

E. CHLORINATE INFLUENT - MAY DO MORE HARM THAN GOOD.

F. USE MASKING AGENT

D. CONDITION OF RAW WATER

1. CAUSE

A. HIGH SULFATES 500 MG/L

B. HIGHLY SALINE OR BRACKISH WATER

2. CORRECTION

A. ADD SUPPLEMENTAL AIR

B. CHLORINATE INFLUENT

(LAGOONS ARE NOT WELL SUITED TO THIS SITUATION)

E. SCUM RAFTS - BLUE-GREEN ALGAE

1. CAUSE

A. WHEN MOWING CUTTINGS MAY BLOW INTO POND.

B. DEAD VEGETATION

C. GREASE OR OTHER IMPROPERLY PRE-TREATED ORGANIC SOLIDS.

2. EFFECT

A. BLUE-GREENS MAY RESULT IN OFFENSIVE DECAYING ODOR.

B. RAFTS MAY HARBOR BOTULISM ORGANISMS CAUSING TOXINS TO BE DISCHARGING TO STREAM WITH RESULTING FISH KILL.

3. CORRECTION

A. BREAK-UP OUTBOARD MOTOR, HIGH PRESSURE HOSE.

B. REMOVE - RAKE, FLOATING BOOM.

C. DREDGE TO REDUCE BOTTOM SLUDGES.

F. EXPLOSIVE GROWTH OF VARIOUS ORGANISMS

1. CAUSE

A. DAPHNIA OR OTHER ZOOPLANKTON.

B. SHRIMP-LIKE ORGANISMS.

C. CHIRONOMID MIDGES.

2. EFFECTS

A. LOW D.O. DUE TO CONSUMPTION BY ORGANISMS.

B. ALGAE POPULATIONS MAY BE DEPLETED.

C. NUISANCE FROM EMERGING FLIES SPREADING TO IMMEDIATE NEIGHBORHOOD.

3. CORRECTION

A. NO ACTION IF NO PROBLEMS ARE CAUSED - USUALLY WILL RUN ITS COURSE AND TAKE CARE OF ITSELF.

B. NATURAL ELEVATION OF PH MAY ELIMINATE ZOOPLANKTON IF THEY BECOME TOO PREVALENT.

C. SHRIMP-LIKE ORGANISMS - DIBROM-8 HAS BEEN USED.

D. MIDGES - INSECTICIDES - PARATHION, ABATE, SURSBAN, FENTHION. CHECK WITH LOCAL AUTHORITIES BEFORE USING.

G. ACID FERMENTATION

1. CAUSE

A. START-UP

B. TOO MUCH MIXING OR RECIRCULATION.

C. MULTIPLE POINTS OF INFLUENT DISCHARGE SPREAD SLUDGE OUT TOO THIN.

2. EFFECTS

A. LOWERING PH.

B. DISCHARGE OF UNSTABLE ORGANICS.

3. CORRECTION

A. SEED LAGOON.

B. CHANGE TO SINGLE INLET TO ALLOW SLUDGE BUILDUP AND STABLE ANAEROBIC DIGESTION.

ERIC

LAGOON - PROBLEM 2
WEEDS, VEGETATION

A. AQUATIC (ROOTS IN WATER)

1. CAUSE

   A. POND TOO SHALLOW.

   B. INVASION FROM SHORE--PARTICULARLY PONDWEED.

   C. TOO SLOW TO FILL.

2. EFFECTS

   A. INSECT HARBORAGE

   B. BLOCKS SUNLIGHT PENETRATION

   C. MAY CAUSE ODORS

   D. INHIBIT REAERATION AND CIRCULATION

3. CORRECTION - KEEP 3' OF WATER IN PONDS

   A. HERBICIDES - TRIAZINE EFFECTIVE (CLEAR WITH AUTHORITIES).

   B. CATTAILS - MUST BE DUG OUT.

   C. WADE AND REMOVE BY HAND.

   D. DRAIN AND REMOVE.

   E. USE HERBICIDE PRIOR TO FILLING.
   UREABOR (U.S. BORAX), TELEVAR OR KARMEX (DUPONT)

   F. FILL RAPIDLY FROM NEARBY STREAM.

   G. FILL FIRST POND THEN DISCHARGE 2' TO SECOND POND AND DIVIDE FLOWS TO BOTH.

   H. ELIMINATE SHALLOW OR SHELTERED AREAS (I.E. <3')

B. TERRESTRIAL

1. CAUSE

A. IMPROPER PREPARATION AND SEEDING OF DIKES.

B. INADEQUATE MOWING.

C. POOR MAINTENANCE OF WATER LINE AREA.

2. EFFECTS

A. MOSQUITO HARBORAGE AT WATERLINE.

B. BLOWING CUTTINGS COLLECT ON POND SURFACE.

C. LEAKAGE CAUSED BY DEEP ROOTED PLANTS AND GRASSES.

D. INHIBIT REAERATION AND CIRCULATION IS OVERHANGING POND.

3. CORRECTION

A. DON'T PLANT ALFALFA, REED CANARY OR OTHER LONG-ROOTED GRASSES.

B. SPOT KILL WEEDS WITH HERBICIDE.

C. APPLY HERBICIDE TO AN AREA 1' ABOVE AND 1' BELOW NORMAL WATERLINE TO PREVENT PROBLEM WITH MOWING AT WATERLINE.

EXCERPTS FROM "MINNESOTA POLLUTION CONTROL AUTHORITY LAGOON MANUAL"
(To be used with Section J)

SECTION I

PUBLIC HEALTH ASPECTS

I-1 PUBLIC HEALTH ASPECTS

STABILIZATION PONDS, LIKE OTHER WASTEWATER TREATMENT FACILITIES, MUST BE TREATED WITH CAUTION AND RESPECT FROM A SAFETY AND PUBLIC HEALTH STANDPOINT BY OPERATORS AND THE GENERAL PUBLIC ALIKE. THIS MEANS THAT STABILIZATION PONDS MUST BE UTILIZED FOR THEIR DESIGNED PURPOSE ONLY, AND NOT FOR PUBLIC RECREATION.

THE RELATIVE AREA OF WATER SURFACE OF STABILIZATION PONDS IS INSIGNIFICANT IN COMPARISON TO THE MANY NATURAL BODIES OF OPEN WATER IN MOST AREAS. IN SOME AREAS, HOWEVER, STABILIZATION PONDS REPRESENT THE ONLY SIZEABLE AREA OF OPEN WATER AND HAVE BEEN SOURCES OF ATTRACTION TO CHILDREN AS WELL AS ADULTS FOR RECREATION PURPOSES. INCIDENTS OF BOATING, ICE-SKATING, EXTENSIVE WATERFOWL HUNTING AND EVEN SWIMMING IN PONDS HAVE BEEN REPORTED. THIS RECREATIONAL USE MUST BE DISCOURAGED AND SAFETY PRACTICES ENCOURAGED FOR SEVERAL IMPORTANT REASONS.

FIRST, EVEN THOUGH THE EFFICIENCY OF BACTERIAL REMOVAL AS MEASURED BY THE MPN METHOD IS VERY HIGH, THE POSSIBILITY OF CONTAMINATION OR INFECTION FROM PATHOGENIC ORGANISMS DOES EXIST WHEN ONE COMES IN CONTACT WITH WASTEWATER IN A STABILIZATION POND.

SECOND, ALTHOUGH MOST STABILIZATION PONDS ATTAIN A DEPTH OF ONLY FIVE FEET, THERE IS STILL SUFFICIENT DEPTH TO DROWN A PERSON. ALSO, THE CLAY LINER USED IN SEALING THE POND BECOMES VERY STICKY WHEN WATER IS ADDED. SHOULD ANYONE FALL IN THE POND, THIS CLAY LINER WOULD MAKE IT EXTREMELY DIFFICULT FOR ANYONE TO GET OUT.

ONE NATURAL FACTOR WHICH DISCOURAGES THE USE OF STABILIZATION PONDS FOR RECREATIONAL PURPOSES IS THE MOSQUIT; HOWEVER, ON A WELL MAINTAINED POND SYSTEM, MOSQUITOES USUALLY DO NOT CAUSE ANY NUISANCE.

ACCORDING TO STUDIES MADE BY THE U. S. PUBLIC HEALTH SERVICE, THE DENSITY OF MOSQUITO POPULATION IS DIRECTLY PROPORTIONAL TO THE EXTENT OF WEED GROWTH IN THE PONDS. WHERE WEED BROWTH IN THE PONDS AND ALONG THE WATER LINE OF THE DIKES IS NEGLIGIBLE AND WHERE WIND ACTION ON THE POND IS NOT UNDULY RESTRICTED, THE PRODUCTION OF MOSQUITOES IN STABILIZATION PONDS IS OF LITTLE CONSEQUENCE.

I-2 PERSONAL HYGIENE

IT IS IN THE INTEREST OF YOUR HEALTH AND THE HEALTH OF YOUR FAMILY THAT THIS LIST OF DO'S AND DON'TS FOR PERSONAL HYGIENE IS MADE. USE, IT DON'T ABUSE IT!

1. NEVER EAT YOUR LUNCH OR PUT ANYTHING INTO YOUR MOUTH WITHOUT FIRST WASHING YOUR HANDS.

2. REFRAIN FROM SMOKING WHILE WORKING IN TANKS, ON PUMPS, TRUCKS, FILTERS ETC. REMEMBER, YOU INHALE OR INGEST THE FILTH THAT COLLECTS ON THE CIGARETTE FROM DIRTY HANDS. SAVE YOUR SMOKING TIME FOR LUNCH HOURS OR AT HOME.

3. A GOOD POLICY IS NEVER PUT YOUR HANDS ABOVE YOUR COLLAR WHEN WORKING ON ANY PLANT EQUIPMENT.

4. DON'T WEAR YOUR WORK COVERALLS OR RUBBER BOOTS TO THE DINING AREA.

5. ALWAYS WEAR YOUR RUBBER BOOTS WHEN WORKING IN TANKS, AROUND SLUDGE, WASHING DOWN ETC. DON'T WEAR YOUR STREET SHOES.

6. KEEP YOUR STREET SHOES IN YOUR LOCKER, REMEMBER THAT WHAT YOUR SHOES PICK UP AT THE PLANT THEY WILL LEAVE ON THE FLOOR OF YOUR HOME.

7. DON'T WEAR YOUR COVERALLS OR RUBBER BOOTS IN YOUR CAR OR HOME.

8. ALWAYS CLEAN ANY EQUIPMENT SUCH AS SAFETY BELTS, HARNESS, FACE MASKS, GLOVES, ETC., AFTER USING. YOU OR SOMEONE MAY WANT TO USE IT AGAIN.

9. HAVE A COMPLETE CHANGE OF CLOTHING TO WEAR WHEN GOING HOME.

10. ALWAYS WEAR RUBBER OR PLASTIC COATED GLOVES WHEN CLEANING OUT PUMPS, HANDLING HOSES OR WHEN WORKING ANYWHERE AROUND THE PLANT.

11. AVOID PUTTING ON WORK GLOVES WHEN YOUR HANDS ARE DIRTY - WASH FIRST.

12. WASH WITH PLENTY OF WATER OR TAKE A SHOWER IMMEDIATELY AFTER BEING SPLASHED WITH SLUDGE OR ANY CHEMICAL - DON'T DELAY.

13. DON'T JUST WASH YOUR HANDS BEFORE GOING HOME, WASH YOUR FACE THOROUGHLY TOO.

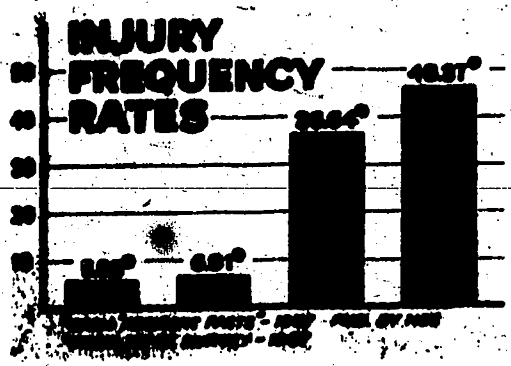
14. WEAR A HARD HAT WHEN WORKING AROUND MANHOLES OR LIFT STATIONS.

15. KEEP YOUR FINGERNAILS CUT SHORT AND CLEAN AS THEY ARE EXCELLENT CARRYING PLACES FOR DIRT AND GERMS.

I-3 SAFETY

THIS MANUAL WOULD NOT BE COMPLETE UNLESS SOMETHING WAS SAID ABOUT SAFETY.

THE WASTEWATER AND POLLUTION CONTROL INDUSTRY HAS THE HIGHEST EMPLOYEE ACCIDENT RATE OF ALL INDUSTRIES IN THE UNITED STATES. A 1967 WATER POLLUTION CONTROL FEDERATION SURVEY SHOWED THAT WASTEWATER SYSTEMS HAD AN INJURY RATE NEARLY EIGHT TIMES THAT OF THE GAS UTILITY INDUSTRY WHICH HAS MOST OF THE SAME HAZARDS. THE INJURY RATE FOR WASTEWATER SYSTEMS WAS OVER SIX AND ONE-HALF TIMES THAT OF THE AVERAGE INDUSTRY, AND NEARLY 25 PERCENT MORE THAN THAT OF THE VERY WORST AMONG THE INDUSTRIES REPORTING TO THE NATIONAL SAFETY COUNCIL !



WE WILL ATTEMPT TO BRIEFLY OUTLINE SOME IMPORTANT SAFETY RULES WHICH SHOULD BE FOLLOWED BY A WASTEWATER TREATMENT FACILITY OPERATOR.

A. SEWER MAINTENANCE SAFETY PRECAUTIONS.

1. REMOVE AND REPLACE HEAVY MANHOLE COVERS CAREFUULY AND ONLY WITH THE PROPER TOOLS. AFTER REMOVAL, LAY THE COVER FLAT ON THE GROUND AT LEAST TWO FEET AWAY FROM THE OPEN MANHOLE.
2. DESCEND INTO ANY MANHOLE CAUTIOUSLY TO GUARD AGAINST SLIPPERY, LOOSE, CORRODED, BROKEN OR OTHERWISE DEFECTIVE STEPS OR RUNGS. REMEDY SUCH DEFECTS IMMEDIATELY, TOGETHER WITH ANY CRACKS OR BREAKS IN THE MANHOLE WALL.
3. WEAR AN APPROVED TESTED SAFETY BELT WITH ATTACHED LIFELINE WHEN ENTERING A SEWER. [redacted]. AT LEAST TWO MEN SHOULD STAND BY OUTSIDE THE MAN-

HOLE TO HANDLE THE LIFELINE IN CASE OF EMERGENCY. EXTRA LENGTHS OF ROPE MUST BE READILY AVAILABLE.

4. ASSIGN A TRAINED PERSON TO SUPERVISE THE CLEANING AND MAINTENANCE OF SEWERS AND ALERT ALL OTHER PERSONNEL TO POSSIBLE HAZARDS AND TO PRECAUTIONS AGAINST THEM.

5. ERECT BARRIERS AND SIGNS AT A SUITABLE DISTANCE FROM OPEN MANHOLES TO ALERT TRAFFIC COMING FROM ANY DIRECTION THAT MEN ARE AT WORK.

B. PUMPING STATION AND STABILIZATION POND SAFETY PRECAUTIONS.

1. MAINTAIN A HIGH LEVEL OF GOOD HOUSEKEEPING. THIS INVOLVES KEEPING FLOORS, WALLS AND EQUIPMENT FREE FROM DIRT, GREASE AND DEBRIS. KEEP TOOLS PROPERLY STORED WHEN NOT IN USE. MAKE MINOR REPAIRS TO STRUCTURES AND APPURTENANCES IMMEDIATELY TO AVOID FURTHER DAMAGE AND POSSIBLE ACCIDENTS.

2. KEEP WALKWAYS CLEAN AND FREE FROM SLIPPERY SUBSTANCES. IF ICE FORMS ON WALKS, APPLY SALT OR SAND OR COVER WITH EARTH OR ASHES THAT CAN BE REMOVED LATER.

3. BE ESPECIALLY CAUTIOUS WHEN WORKING WITH AN ELECTRICAL DISTRIBUTION SYSTEM AND RELATED FACILITIES. NEVER WORK ON ELECTRICAL EQUIPMENT AND WIRE WITH WET HANDS OR WHEN CLOTHES OR SHOES ARE WET. ALWAYS WEAR APPRO-

PRIATE SAFETY GLOVES FOR ELECTRICAL WORK. NEVER USE A SWITCHBOX FOR ANYTHING OTHER THAN A SWITCHBOX.

4. KEEP ALL PERSONNEL SAFETY CONSCIOUS BY REMINDING THEM OF SPECIFIC SAFETY INSTRUCTIONS. SUCH INSTRUCTIONS SHOULD INCLUDE INFORMATION ON HOW TO CONTACT THE NEAREST MEDICAL CENTER AND FIRE STATION, RESCUE TECHNIQUES, RESUSCITATION AND FIRST AID TECHNIQUES.
5. MAKE CERTAIN THAT A SUFFICIENT NUMBER OF CAPABLE PERSONNEL WITH PROPER EQUIPMENT ARE ASSIGNED AND PRESENT WHENEVER IT IS NECESSARY TO PERFORM ANY HAZARDOUS WORK.
6. A LIFE PRESERVER MUST BE USED WHEN USING A BOAT ON STABILIZATION PONDS. ALSO, NEVER WORK ALONE AROUND THE PONDS TO PREVENT DROWNING AND OTHER ACCIDENTS. ONE OF THE REQUIREMENTS FOR A POND OPERATOR SHOULD BE THAT HE CAN SWIM AT LEAST 100 FEET IN NORMAL WORK CLOTHING.
7. WARNING SIGNS SHOULD BE INSTALLED NEAR DANGEROUS MACHINERY OR AT ANY LOCATION INVOLVING A STUMBLING HAZARD. THE SIGNS SHOULD BE DESIGNED AND LOCATED TO CALL ATTENTION TO A SPECIFIC DANGER AND DISCRETION MUST BE USED IN DETERMINING THE NUMBER AND PLACEMENT OF SIGNS SO PERSONNEL WILL PAY MAXIMUM ATTENTION TO THEM.
8. SUFFICIENT FIRE EXTINGUISHERS (UNDERWRITER'S LABORATORIES APPROVED) SHOULD BE PLACED IN READILY ACCESSIBLE

ERIC

LOCATIONS.

C. BODY INFECTION AND DISEASE SAFETY PRECAUTIONS.

1. TREAT ALL CUTS, SKIN ABRASIONS AND SIMILAR INJURIES PROMPTLY. WHEN WORKING WITH WASTEWATER, THE SMALLEST CUT OR SCRATCH IS POTENTIALLY DANGEROUS AND SHOULD BE CLEANED AND TREATED IMMEDIATELY WITH A 2% SOLUTION OF TINCTURE OF IODINE.
2. SEE A DOCTOR FOR ALL INJURIES.
3. PROVIDE FIRST AID TRAINING FOR ALL PERSONNEL.
4. BE INNOCULATED FOR WATERBORNE DISEASES, PARTICULARLY TYPHOID AND PARATYPHOID FEVER. KEEP A RECORD OF ALL IMMUNIZATIONS IN AN EMPLOYEE HEALTH RECORD TO ASSURE YOURSELF OF RECEIVING UP TO DATE BOOSTERS, ETC.
5. KEEP FINGERS OUT OF NOSE, EYES AND MOUTH BECAUSE THE HANDS CARRY MOST INFECTIONS IN THIS FIELD OF WORK.
6. AFTER WORK, BEFORE EATING AND AT OTHER CONVENIENT TIMES, WASH HANDS THOROUGHLY WITH PLENTY OF SOAP AND HOT WATER. KEEP FINGERNAILS SHORT AND REMOVE ALL DIRT AS OFTEN AS POSSIBLE WITH A NAIL FILE, OR A STIFF, SOAPY BRUSH.
7. IN LABORATORY WORK, USE PIPET BULBS RATHER THAN THE MOUTH SO AS NOT TO INTRODUCE CONTAMINATION TO THE MOUTH. DON'T DRINK WATER FROM LABORATORY GLASSWARE. PAPER CUPS SHOULD BE PROVIDED IN LABORATORIES FOR

MIXTURES SOMETIMES ACCUMULATE IN SEWERS AND MANHOLES WHERE ORGANIC MATTER HAS BEEN DEPOSITED AND HAS UNDERGONE DECOMPOSITION. THE ACTUAL HAZARDS FROM SEWER GAS EXIST IN THE EXPLOSIVE AMOUNT OF METHANE OR IN OXYGEN DEFICIENCY.

2. CHLORINE. CHLORINE GAS, WHICH IS IRRITATING TO THE EYES, RESPIRATORY TRACT AND OTHER MUCOUS MEMBRANES, MAY SETTLE IN LOW, STILL AREAS. THE GAS ESCAPES BY LEAKAGE FROM CYLINDERS AND FEED LINES AND FINDS ITS WAY TO THESE PLACES.

SAFETY PRECAUTIONS TO FOLLOW IN SITUATIONS WHERE THE PRESENCE OF GAS IS POSSIBLE SHOULD INCLUDE:

1. PROHIBIT SMOKING AND OPEN FLAMES IN AND AROUND OPEN MANHOLES, SEWERS AND WETWELLS, AS GASOLINE OR PETROLEUM VAPORS, ILLUMINATING GAS AND METHANE ARE COMMON IN THESE AREAS. USE ONLY PERMISSIBLE EXPLOSION PROOF LIGHTS, ELECTICAL FIXTURES, MOTORS AND OTHER EQUIPMENT IN ALL SUCH DANGEROUS AREAS.
2. MAKE PERIODIC CHECKS FOR GAS LEAKS IN CHLORINE ROOMS TO PRECLUDE ACCIDENTS.
3. VENTILATION SHOULD BE PROVIDED WHEN ENTERING WET WELLS, LIFT STATIONS, CHLORINE ROOMS AND MANHOLES.
4. USE OXYGEN DEFICIENCY INDICATORS AND HAVE GAS MASKS WITH AN O_2 SUPPLY ON HAND WHEN WORKING IN ANY LOCATION THAT HAS A POTENTIAL GAS HAZARD.

5. USE EXTREME CAUTION WHEN HANDLING CHLORINE. THE TEST FOR A CHLORINE LEAK IS TO SOAK A RAG IN AMMONIA AND HOLD IT IN THE AREA OF A SUSPECTED LEAK. IF A LEAK HAS OCCURRED, A WHITE CLOUD WILL EMINATE FROM THE AMMONIA SOAKED RAG.

I-4 SAFETY EQUIPMENT

THE TYPES OF SAFETY EQUIPMENT WHICH A WASTEWATER FACILITY SHOULD HAVE ARE AS FOLLOWS:

1. DETECTION EQUIPMENT (FOR GASES AND OXYGEN DEFICIENCIES).
2. MASKS (SELF CONTAINED AIR PACKS FOR OXYGEN DEFICIENCIES).
3. SAFETY HARNESSES, LINES AND HOISTS.
4. PROPER PROTECTIVE CLOTHING, FOOTWEAR, AND HEAD GEAR.
5. VENTILATING EQUIPMENT.
6. NON-SPARKING TOOLS.
7. COMMUNICATIONS EQUIPMENT.
8. PORTABLE AIR BLOWER.
9. EXPLOSION-PROOF LANTERN AND OTHER SAFE ILLUMINATION.
10. WARNING SIGNS AND BARRIERS.
11. EMERGENCY FIRST AID KITS.
12. PROPER FIRE EXTINGUISHERS.
13. EYE WASH AND SHOWER STATIONS IN LABORATORY AREAS.
14. SAFETY GOGGLES FOR WORK IN LABORATORIES AND OTHER DANGEROUS AREAS.

ADDITIONAL SOURCES OF INFORMATION

- NEW YORK MANUAL, CHAPTER 14
- WPCF, MOP #1, SAFETY IN WASTEWATER WORKS
- TEXAS MANUAL, CHAPTER 35
- SACRAMENTO STATE HOME-STUDY COURSE, CHAPTER 12.

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STABILIZATION POND OPERATION

HIGH-RISK ACTIVITIES

REMOVING DEBRIS FROM CHANNELS

REMOVING DEBRIS FROM POND

REMOVING VEGETATION NEXT TO ELECTRICAL WIRE

WORKING IN BOAT

WORKING WITH SWITCHES IN AUTOMATIC POSITION

SOURCES OF DANGER

ACID WASTES

BOAT AND MOTOR

CAUSTIC WASTES

CHUCK HOLES

CONTAMINATION BY CONTACT

ELECTRICAL EQUIPMENT

ELECTRICAL WIRES IN DAMP AREAS

HERBICIDES

HOLES IN FENCE

MOVING PARTS

OPEN DOORS AND COVERS

PESTICIDES

SHORT CIRCUITS

SLIPPERY DIKES

SLIPPERY WALKS

SOIL STERILIZERS

TOXIC GASES

UNDERCUT BANKS

UNDERGROUND CONTROL PANEL

SOURCES OF DANGER (CONTINUED)

- WELLS
- WET GRASS
- WET ROCKS

SAFETY EQUIPMENT

- ADEQUATE LIGHTING
- BARRICADES
- ENCLOSED ELECTRICAL WIRES
- FENCES
- FIRE-FIGHTING EQUIPMENT
- FIRST-AID KIT
- LIFE PRESERVER
- LOCKOUT TAGS AND KEYS
- LOCKS
- PROTECTIVE CLOTHING
- RAILINGS
- SAFETY EQUIPMENT IN BOAT
- SIGNS

ANSWERS TO QUESTIONS

Section A

1. 2 - 3 feet (Page A1)
2. 1 foot for every 4 foot
3. Cell 1 - 380 x 575/43,560 = 5 acres

   Cell 2 - 5 acres

   Cell 3 - 380 x 380/43,560 = 3.3 acres

   Total - 10.3 acres

Section B

1. Anaerobes (Page B1)
2. Facultative (Page B1)
3. Aerobes (Page B2)
4. 0.4 pounds (Page B2)
5. Afternoon sunrise (Page B5)
6. Oxygen (Page B6)
7. Pathogens (Page B8)
8. Fecal coliform (Page B8)

   185 x 88/100 = 163

   185 - 163 = 22 ppm

   Check: 163/185 x 100 = 88

Section C

1. 2 or 3 (Page C2)
2. One at a time (Page C2)
3. Septicity or overload on green algae growth not well established (Page C4)

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Section D

1. 1. Control of liquid level (Page D1)
   2. Rate of effluent discharge (Page D2)
   3. Scum control (Page D3)
   4. Odor control (Page D4)
   5. Flow measurement and recording (Page D5)
   6. PH (Page D6)
   7. Alkalinity (Page D7)

2. Three, four (Page D2)

3. Low (Page D5)

4. Above (Page D6)

5. 72,000/650 = 111 gallons per capita per day

6. Cell 1 - 380 x 575 x 1 x 7.5/12 = 136,562 gal. per inch

   Cell 2 - 136,562 gal. per inch

   Cell 3 - 380 x 380 x 1 x 7.5/12 = 90,250 gal. per inch

7. 90,250 x 36/900,000 = 3.6 days

8. 136,562 x 12/130,000 = 12.6 days

9. Low (Page D7)

10. Below

Section E

1. Edges or shoreline (Page E1)

2. 1. Organic overloading
   2. Algae bloom
   3. Excess pond depth
   4. High water temperature
   5. Winter freezing
   6. Toxic wastes

3. No (Page E8)

Section F

1. 8 x 100 = 800 pounds (Page F1)

2. 4 x 4.5 = 18 pounds (Page F1)

Section G

1. Centrifugal (Page G1)

2. Air-lock (Page G2)

3. Air-lock (Page G2)

4. Rattle, vibrate, or run hot (Page G2)

5. 1. Compressed air bubbler systems (Page G3)
   2. Recirculated water systems
   3. Floats
   4. Electrical probes
   5. Sealed, submerged pressure bulb systems

6. Several turns, one-quarter (Page G9)

7. Plug (Page G9)

Sections H and I

1. Sunrise,mid-afternoon (Page H3)

2. Glass (Page H4)

3. 1. Sample (Page I1)
   2. Test (Page I2)
   3. Compute results (Page I2)
   4. Record results (Page I2)
   5. Interpret results (Page I3)
   6. Report (Page I4)

4. 0.036 x 8.34 x 175 = 52.5 pounds BOD per day

5. Series

   300 x 400/43,560 = 2.75 acres

   0.031 x 8.34 x 212 = 54.8 pounds BOD per day

   54.8/2.75 = 19.9 pounds BOD per acre per day

   Parallel

   2 x 300 x 400/43,560 = 5.5 acres

   54.8/5.5 = 10 pounds BOD per acre per day

FINAL EXAM

1. A one-acre lagoon will provide wastewater treatment for ______________ people.

2. A lagoon is discharging effluent at 200 G.P.M. Raw wastewater is flowing into the lagoon at a rate of 200,000 gallons per day. Will the level of the lagoon go up, go down, or remain constant? ______________.

3. Complete the following:

   A. 1 gallon of water = ______________ pounds.

   B. 1 cubic foot of water = ______________ gallons.

   C. 1 acre = ______________ square feet.

   D. 250,000 gallons per day = ______________ MGD.

4. A lagoon receives 100 pounds of raw BOD per day. The lagoon removes 92% of the BOD before discharge. How many pounds of BOD per day are discharged?

   ______________.

5. A community has a two-cell lagoon system. All raw wastewater is flowing into cell one. Flow from cell one then enters cell two. The overflow from cell two is discharged. This would be called ______________ operation. (series or parallel).

6. What are the two main reasons for having stabilization ponds securely fenced.

   ____

   ____

7. Algae growth in a lagoon is treating raw domestic wastewater is a ______________ sign. (good or bad).

8. A community has a two-cell lagoon system. The lagoons have a total surface area of 7 acres. The lagoons are receiving 350 pounds of BOD per day. Would you consider this system to be overloaded? (yes or no) ______________. What is the BOD loading? ______________.

9. A lagoon has slopes of 4:1. This means that the influent end of the lagoon is four times deeper than the effluent end. (true or false) ________________.

10. A one-cell lagoon has a total volume of 1,500,000 gallons. The average daily flow into the lagoon is 12,500 gallons per day. What is the average detention time? ________________ days.

11. What is generally the cause of rooted weeds in a lagoon? ________________.

12. A community with a population of 840 has a three-cell lagoon treatment facility. The flow into the lagoon facility is 115 gallons per capita per day. Would you consider that to be a reasonable flow for this community? (yes or no) ________________. What is the total flow in gallons per day? ________________.

13. Generally, the minimum operating depth for a lagoon is ________________ feet.

14. ________________ organisms are especially sensitive to low pH conditions.

15. How can an air locked pump be corrected? ________________.

16. Raw wastewater with a BOD of 150 mg/l is flowing into a lagoon. The average daily flow is 45,000 gallons per day. How many pounds of BOD per day are flowing into the lagoon? ________________.

17. Why are lagoon dikes generally rounded at the corners? ________________.

18. It is early winter. The lagoon is beginning to become ice covered. Should the depth of the lagoon be nearer 2 feet in depth or 5 feet in depth?

________________.

19. A control structure has a weir built into it. What is the purpose of a weir?

________________.

FINAL EXAM ANSWERS

1. 100
2. Go down
3. A. 8.34

   B. 7.48 or 7.5

   C. 43,560

   D. 0.250
4. 8 pounds per day
5. Series
6. Keep out livestock

   Deter trespassing (keep out people)
7. Good
8. No

   50 pounds BOD per acre per day
9. False
10. 120 days
11. Pond depth is too shallow
12. Yes

    96,600 gallons per day
13. 2 or 3 feet
14. Aerobic
15. Bleeding air from it
16. 56
17. To minimize accumulations of floating materials
18. 2 feet
19. To measure flow
20. Up

    34,000 gallons per day