BIOLOGICAL WASTE TREATMENT USING THE BIOLAC SYSTEM

A TECHNICAL NOTE

September 1986

Prepared For:

U.S. Environmental Protection Agency
Office of Municipal Pollution Control
Municipal Facilities Division
401 M Street, S.W.
Washington, D.C. 20460

Prepared By:

Environmental Resources Management, Inc.
999 West Chester Pike
West Chester, Pennsylvania 19382

ACKNOWLEDGMENTS

ERM wishes to thank Charles Morgan of the Parkson Corporation (Fort Lauderdale, Florida) and Carl Janson of Riordan Materials, Haverford, Pennsylvania, for their willingness to discuss the characteristics, design, and performance of the BIOLAC system.

This report is a technical assessment of the BIOLAC System, based entirely on data obtained from the manufacturer of the BIOLAC system and on accepted theories of biological treatment. It was prepared for the Office of Municipal Pollution Control under contract number 68-01-7108. The information was compiled to assist those involved in the innovative and alternative technology program. This document has not been subjected to the agency's peer and administrative reviews, and therefore does not necessarily reflect the views of the agency.

TABLE OF CONTENTS

I. Description of Process and System Design

A. Process and Process Options

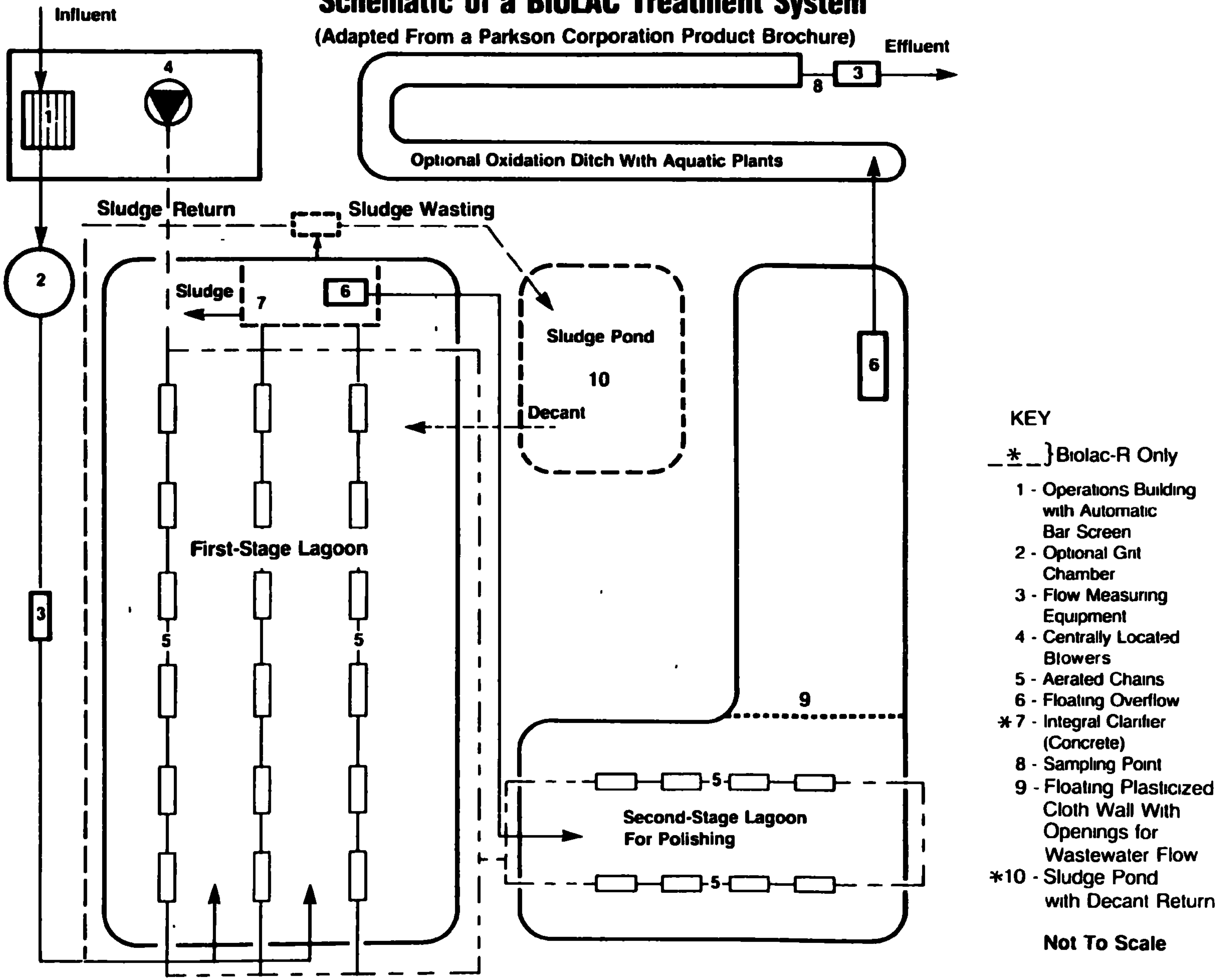
BIOLAC is a complete biological treatment system for municipal and industrial wastewaters. BIOLAC, an acronym for "Biological Wastewater Treatment System using Aeration Chains", consists of an earthen basin, or lagoon, with floating aeration chains intended to aerate and mix the wastewater. Additional aerated or unaerated polishing lagoons and a final channel for nutrient uptake are optional. The design goal is direct discharge of clarified effluent of secondary treatment quality or better to a receiving stream. Some wastewaters may require pretreatment or post-chlorination. Parkson Corporation, which markets BIOLAC, offers two systems for different applications, as shown in Figure 1 and described below:

BIOLAC-L. An aerobic, flow-through system for the biological treatment of domestic wastewater with organic loadings of 30 to 300 pounds of BOD per day. In this system, wastewater flows from a first-stage lagoon into a second-stage polishing lagoon with a quiescent solids settling zone at one end, and then into an optional channel containing nutrient-removing aquatic plants. Polishing consists mostly of additional solids settling.

BIOLAC-R. An extended aeration/activated sludge system for the treatment of domestic and/or industrial wastewaters with organic loadings of 300 to 30,000 pounds of BOD per day. Unlike BIOLAC-L, BIOLAC-R features an integral concrete clarifier with sludge return at the end of the first-stage lagoon, and a sludge storage pond with decant to the first-stage lagoon. The stored sludge is claimed to develop a five to ten percent solids content.

There are notable differences between the design, intended application and performance of BIOLAC-L and BIOLAC-R. For instance, BIOLAC-L is designed to be a flow-through system without appreciable solids retention time, while BIOLAC-R is designed to be an extended aeration system with 20 to 30 days of solids retention time. Also, while BIOLAC-L is intended for treatment of domestic wastewaters with relatively low organic loading, BIOLAC-R is intended for domestic or industrial wastewaters of much higher organic loadings. In addition, BIOLAC-R is capable of removing greater amounts of BOD, yet maintaining a lower biological solids concentration through extended aeration. In contrast, BIOLAC-L is capable of relatively low BOD removal and is designed to maintain a certain hydraulic detention time, rather than a particular biological solids retention time. The

Figure 1
Schematic of a BIOLAC Treatment System
(Adapted From a Parkson Corporation Product Brochure)



manufacturer believes that the unique features of BIOLAC-R are more applicable for meeting the more stringent discharge limitations placed on domestic and industrial wastewaters.

Aeration Chains. Both the BIOLAC-L and BIOLAC-R systems are equipped with floating "aeration chains", shown in Figure 2, for mixing and aeration. Wyss™ flexible sheath diffusers are suspended from the floats of these aerated chains, which are anchored to the edge of the lagoon by stainless steel cables.

1. Design Parameters and Assumptions

BIOLAC design parameters are similar to those of conventional biological systems. Table 1 compares typical design criteria for BIOLAC-L with conventional flow-through aerated lagoons and BIOLAC-R with extended aeration/activated sludge systems. Table 1 shows that the BIOLAC-L system design, like the aerated lagoon, is based on hydraulic detention time rather than organic loading or biomass requirements. The six to fifteen days of detention time recommended for BIOLAC-L is a somewhat higher range than the typical aerated lagoon detention time of three to ten days. In addition, BIOLAC's manufacturer predicts that power requirements for mixing BIOLAC aeration basins are much less than the typical ones for mixing conventional aerated and extended aeration lagoons, as shown in Table 1.

The conventional extended aeration lagoon is designed for an F:M ratio of between 0.05 and 0.15 pounds of BOD per pound of MLVSS, while the BIOLAC-R system is designed for a ratio of 0.03 to 0.10 in order to minimize sludge yields. The recommended MLSS concentration range is also somewhat lower for BIOLAC-R than for the conventional system. The manufacturer claims that nitrification will also occur in the extended aeration basin (first stage lagoon).

2. Typical Operating Conditions

For the BIOLAC aeration system, Parkson suggests a minimum standard oxygen transfer rate of four to five pounds of oxygen per horsepower-hour, a minimum of 0.08 to 0.12 aerator horsepower per 1,000 cubic feet of lagoon volume for mixing, ten-to fifty-foot spacing between aeration chains, and 9 to 30 inches of clearance for diffusers above the bottom of the lagoon. Each float assembly is equipped with either two or four Wyss™ flexible sheath diffusers, each of which provides one to five standard cubic feet of air per minute. Four diffusers could thus provide up to twenty standard cubic feet of air per minute. Aeration chains are typically between 30 and 400 feet in length. The EPA document, EPA 625/8-85-010, indicates that EPA has studied the Wyss™ diffusers and classified them as fine bubble diffusers. The

Figure 2
Schematic of a BIOLAC Aerated Chain System

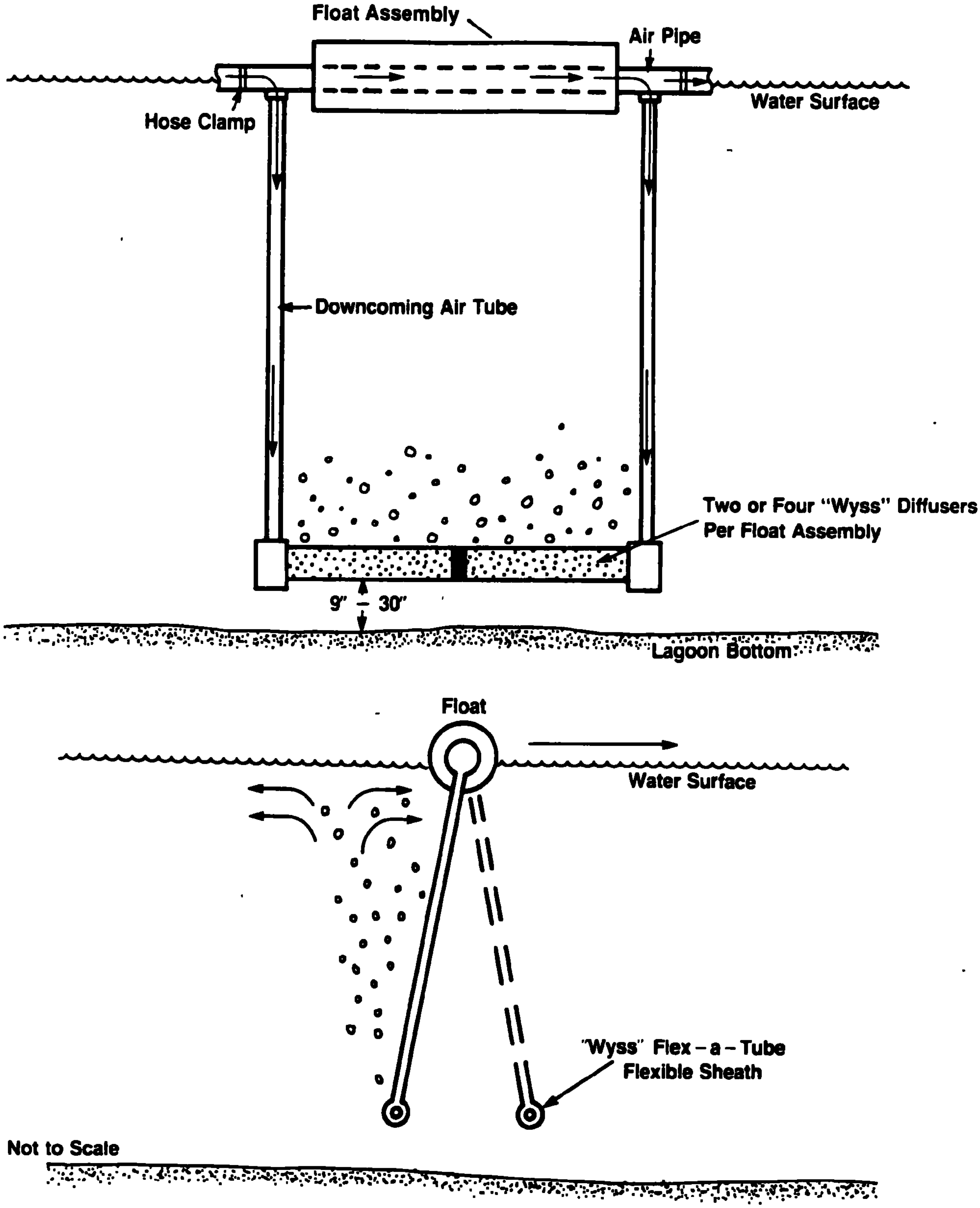


TABLE 1

MANUFACTURER'S DESIGN CRITERIA FOR BIOLAC SYSTEMS IN COMPARISON WITH AERATED LAGOONS AND EXTENDED AERATION/ACTIVATED SLUDGE

	Design Criteria			
Parameter	Aerated Lagoon*	Biolac-L**(1)	Extended Aeration/* Activated Sludge	Biolac-R**(1)
Lagoon Depth, Feet	6 to 20	8 to 20	Not Applicable	8 to 20
Hydraulic Detention Time, Days	3 to 10	6 to 15	.75 to 1.5	1 to 2
Food:Microorganism Ratio, lb. BOD_5/day/lb. MLVSS	Not Applicable	Not Applicable	0.05 to 0.15	0.03 to 0.10
BOD Removal, %	80 to 95%	90%, typically	75 to 95%	99%, typically
MLSS, mg/l	NR	NR	3,000 to 6,000	1,500 to 5,000
Solids Retention Time (SRT) days	3 to 6	NR	20 to 30	50 to 70
Effluent TSS, mg/l	260 to 300	NR	20 to 30	NR
Aeration Basin Mixing Requirement (HP/MG of basin volume)(1)	70 to 130(2)	3-6 HP/MG (Typical)	130 to 200(2)	12 to 15 HP/MG
Sludge Recycle Ratio	Not Applicable	Not Applicable	0.75 to 1.50	Adjustable

NR: Not Reported
* Reference: Metcalf and Eddy, Inc., Wastewater Engineering, 1972.
** Reference: Parkson Corporation

1 Data from manufacturer, Parkson Corporation
2 Horsepower required for mixing, which is typically greater than that for oxygen demand in the systems noted.

EPA report does not indicate, however, that the Wyss™ diffusers meet the ASCE criteria for fine bubble diffusers. When fully charged with air, the manufacturer notes, the air bubbles approach medium size.

3. Major Equipment

BIOLAC-L and BIOLAC-R systems both require air blowers, aeration system controls, influent and effluent pumps, and overflow weirs. Temperature and pH recorders are optional. BIOLAC-R also requires an integral clarifier, a sludge airlift pump and possibly a sludge wasting pump. Lagoon liners may be required to meet environmental requirements.

B. Existing and Proposed Installations

Of the 100 BIOLAC systems operating in Europe, performance data are available for only three: BIOLAC-R systems located in Konigslutter, Rot am See, and Bielefeld, West Germany. At ten sites, substitution of existing aeration systems with aeration chains (a type of retrofit) has occurred. Site locations include Franklin, Ohio, and Pierrepont Manor, New York. Eight other retrofits are planned for installation, are currently being installed, or are in a start-up phase for the treatment of domestic, poultry, industrial wastewater in the United States. One BIOLAC-R project has been granted funding under the EPA's Innovative/Alternative Program. It will be located in Columbiana, Alabama (EPA Region IV).

C. Manufacturer's Claims

According to the Parkson Corporation, the BIOLAC system is applicable to any biodegradable wastewater and incorporates many proven treatment processes in a highly efficient and innovative way. Presently, German BIOLAC installations treat food and beverage industry as well as domestic wastewaters with organic loadings ranging from 40 to 22,000 pounds per day of BOD and flow rates ranging from 0.01 to 1.6 MGD. In comparison with conventional extended aeration/activated sludge systems, the BIOLAC system is claimed to have greater system stability, equal or better BOD removal capability, reduced sludge production and greater nitrification (BIOLAC-R only), and lower construction, operating, and maintenance costs. The manufacturer attributes these benefits to the longer design SRT used. Major advantages cited are the efficient use of submerged, flexible sheath diffusers, earthen lagoons, and the system's ability to perform at low organic loading rates and in cold climates.

II. Evaluation of Design Procedure - New Construction and Retrofits

A. Design Procedure Recommended by the Manufacturer/ Supplier

Information on specific procedures used in the design of existing plants was not available. However, the manufacturer recommends a design based on conventional parameters (source, quality and flow rate of wastewater, the desired effluent quality) and the design criteria indicated in Table 1. A treatability study is recommended prior to design, particularly for wastewaters with a significant industrial component, in order to optimize the system design. Following system installation, the manufacturer emphasizes the need to monitor the lagoons for dissolved oxygen, temperature, and pH, as is advisable with any aerobic treatment system. However, the manufacturer believes that less monitoring effort is needed than with conventional systems.

Generally, for domestic wastewaters at less than 200,000 gpd a BIOLAC-L system is recommended, while BIOLAC-R is recommended for higher municipal flows and industrial wastewaters. Each wastewater should be evaluated for selection of the type of system to be applied. To provide extended aeration and desired effluent quality, BIOLAC-R lagoons are designed to provide specific ranges for hydraulic retention time, food to microorganism ratio, and MLSS. The BIOLAC-R sludge storage pond is typically sized to provide at least six months of storage to allow stored sludge to dewater to a predicted five to ten percent solids.

Parkson does not provide specifics on retrofitting an existing lagoon, but indicates that performance data for the lagoon will determine whether its size is adequate for the intended treatment. The manufacturer claims that a conventional lagoon can be modified to resemble a BIOLAC system.

Replacement of existing surface aerators or fixed diffusers with aerated chains is recommended to improve mixing, lessen aeration energy requirements (versus surface aerators and coarse bubble diffusers), simplify maintenance and reduce maintenance costs.

For both new construction and retrofits, the aeration chain system is designed according to the selected lagoon depth, the wastewater quality and flow rate, seasonal temperature fluctuations, and the oxygen demand of the wastewater. The required air discharge pressure and blower capacity are determined from this information and the design of the Wyss™ diffusers.

The manufacturer claims that the aeration chains provide adequate mixing at much less energy than that required for aeration and, therefore, the aeration system design is controlled by the aeration requirements. This contrasts with the practice of sizing conventional lagoon aeration systems on the basis of mixing requirements.

The manufacturer recommends that the second lagoon be installed in every BIOLAC system in order to provide additional buffering capacity for handling peaks in organic concentrations and hydraulic loads. The buffer is intended to reduce the level of operator attention required.

B. Comments on the Design Procedure

Since BIOLAC systems utilize conventional treatment processes and are designed on the basis of well-established principles of biological treatment, their design procedure is correct in theory. However, since specific documentation on the design procedures is not available, further information is necessary to verify the basis of the design. The use of submerged diffusers should reduce drops in lagoon temperature. It is not clear how much benefit is provided by the second aeration lagoon in BIOLAC-R, since about 95 percent of the treatment occurs in the extended aeration lagoon.

III. Evaluation of System Performance

A. Manufacturer's Claims

No opportunity was available to compare the manufacturer's claims with reports from actual BIOLAC operators in Europe. The manufacturer feels that the wide application of the BIOLAC in Europe attests to its high performance. In addition, two BIOLAC-R and ten individual aeration chain systems have been sold, and will begin operating by mid-1987.

B. Availability and Suitability of Existing Operations Data

More design and operational data are needed to fully evaluate the BIOLAC treatment concept. For example, only limited case histories from three West German BIOLAC-R plants are available, although they show high BOD removals and represent a wide range of influent flows. None of the available operations data pertain to BIOLAC-L plants, and none include percent removals of suspended solids, the degree of dewatering in the sludge settling ponds, or performance during an entire winter or over the long term.

Only one case history provided data for nitrification and COD removals. Furthermore, only a limited amount of design data (BOD loadings and population equivalents) are available for comparing specific BIOLAC designs to actual plant construction and performance.

IV. Level of Confidence in the BIOLAC Treatment Concept

A. BIOLAC Process Innovations

The BIOLAC system employs several unproven design features. These include:

1. The efficient use of submerged flexible sheath diffusers in a large volume, earthen lagoon system, which is predicted to increase oxygen transfer efficiency and reduces capital cost;

2. The use of low F:M ratios and longer solids retention times in an economical system (relative to lagoons with conventional aeration systems), to produce a low-volume, well-stabilized sludge and to achieve process stability, high BOD removal, and nitrification;

3. The use of integral clarifiers to reduce construction costs (BIOLAC-R only); and

4. The use of "aeration chains" to "sweep" the lagoon, reducing the mixing horsepower requirements.

Critical design variables for BIOLAC are solids retention time, hydraulic detention time, organic loading, and aeration horsepower requirements.

B. Basis for Assigning a Good Level of Confidence

ERM can assign a good level of confidence to the theory of the BIOLAC concept for the treatment of wastewater in the United States. However, due to incomplete design and operational data, and the fact that as of September 1986, there are no operational non-retrofit BIOLAC installations in the United States, use of the BIOLAC system would carry "relatively high technological risk" according to guidelines issued by EPA. Therefore the BIOLAC system would fall under "Area A: Field Test to Verify Design for Innovative Designation," of Figure 1: Window of Risk, as shown in the "Guidance on Designating Projects as Innovative," (USEPA, Office of Municipal Pollution Control). The recent EPA grant for a BIOLAC-R system in Alabama may serve as this field test. If so, successful operation of this BIOLAC-R may allow BIOLAC to be later designated as having the potential for further designation as Innovative. However, the fact that there are over 100 operating systems in Europe is a very strong indication that the system could have successful application in the United States. In addition, two complete BIOLAC-R and ten individual aeration chain systems are scheduled for start-up in mid-1987. Furthermore, no new treatment theories are apparently used in the BIOLAC design; all components of the BIOLAC system appear to be designed on the basis of accepted, conventional theories of biological treatment.

No final conclusion about the performance of the aeration chain systems can be made. The manufacturer reports no mechanical failures to date but recommends an annual inspection of the aeration system.

C. Benefits of Strengthening Certain Parameters Via a Field Test

Field tests would improve BIOLAC design guidelines for similar treatment applications, and thereby increase the probability that such a system would perform well and not require additional expenditures for system modifications. Design criteria could be strengthened for particular wastewater types and climates, and the system components could be sized more accurately.