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Project Summary

Evaluation and Control of Sidestreams Generated in Publicly Owned Treatment Works

Roy Ball, Michael Harris, and Kevin Deeny

The document on which this project summary is based provides methodologies and considerations for evaluating and controlling sidestreams generated in publicly owned treatment works (POTW's). The methodologies are structured in algorithms.

These algorithms are used initially to determine whether one or more sidestreams are impacting on mainstream process performance. Once an impact on process performance is determined, additional algorithms present operational procedures for controlling the impact of the sidestream, either at the mainstream process or at the source of the sidestream.

Through the proper use of the algorithms, a point is reached where all applicable operational methods to reduce the sidestream impact have been performed. Decision points included in the algorithms refer the user to design methods to control sidestream impacts in the event that all of the operational methods have been unable to reduce the impacts to acceptable levels.

In addition, sidestream characterization data are appended to the full report to provide available information for design purposes.

The methodologies for evaluating and controlling sidestreams in POTW's are not intended to represent all of the available means, nor are they each intended to apply to all POTW's. The algorithms are somewhat complex so they can be applied to a wide range of treatment plants with differing design and operational features. The ultimate user will tailor and apply the algorithms to the individual treatment plant; therefore, the complexity of the algorithms will be directly related to the specific treatment plant for which they are used.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

POTW's have been mandated by the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500) and the Clean Water Act of 1977 (Public Law 92-215) to discharge only effluents that have attained certain levels of treatment. In general, the treatment processes required to meet these discharge standards are a combination of unit operations and unit processes.

In general, the more stringent the discharge standard, the greater are the amounts and types of sludges generated by a POTW. This results in many types of sludge handling or treatment operations and processes being required to ensure proper overall system performance. In addition to producing sludges that must be adequately disposed of, sidestreams are generated that must also be treated.

Many performance problems at POTW's are allegedly the result of recycling these sidestreams within the POTW. Sidestreams often carry significant quantities of organic and inorganic materials either in solution or suspended form. Although the volume of these sidestreams is generally small as compared with the influent flow of the POTW's, returning these sidestreams to the influent of the POTW can significantly increase the organic and solids loading to the POTW. The significance of the potential impact on mainstream processes depends on a number of factors that include the percent of plant design capacity in service, combinations of processes used, and specific design and operating features of the plant. Generally, however, most mainstream processes should be capable of handling any sidestream generated at a POTW.

Once the matrix was completed, definitive procedures to assess the impact of sidestreams had to be developed to be applied at POTW's. Following the assessment, specific operational methodologies and design information had to be developed to use in reducing the impact of sidestreams on POTW's.

The first step in evaluating and controlling sidestream impact is to define whether a sidestream is indeed responsible for an observed loss in performance in a mainstream process.

Since POTW's may differ significantly in the number and type of processes that are used at the facility, a flexible, systemized approach for evaluating sidestream impacts was developed. This approach uses algorithms that are similar to logic flow diagrams. An algorithm developed for each of the mainstream processes considered in this report is to be used as a guideline in evaluating the impact of sidestreams on the mainstream processes.

To determine whether sidestreams are responsible for losses in performance, the user must select the appropriate algorithm for the specific POTW and complete the work outlined in the algorithm before any other activity is initiated. In the event that a sidestream impact is confirmed through the use of the evaluation procedure outlined in the algorithm, the user is referred to operational methods and design information (contained in the report) that can be used to control the impact. The systemized approach using algorithms is also used to present operational methods to control the sidestreams impact.

The overall approach for using the information in this report is shown graphically in Figure 1 and briefly discussed below.

Algorithms applicable to the specific POTW are selected by the user and used as guidelines in determining whether sidestreams are impacting mainstream processes. Impacts, once determined are recorded on a checklist for reference. At this point, the user must determine whether any of the impacts had been previously considered or are new to the checklist. If the impacts have not been previously considered, the user is directed to operational information (in algorithm format) to assist in controlling the impact(s). A checklist for operational information is used to keep track of recommended activity. Ultimately, the recommendations are to be carried out at the POTW.

To determine whether the recommended changes have been partially or fully successful in controlling the

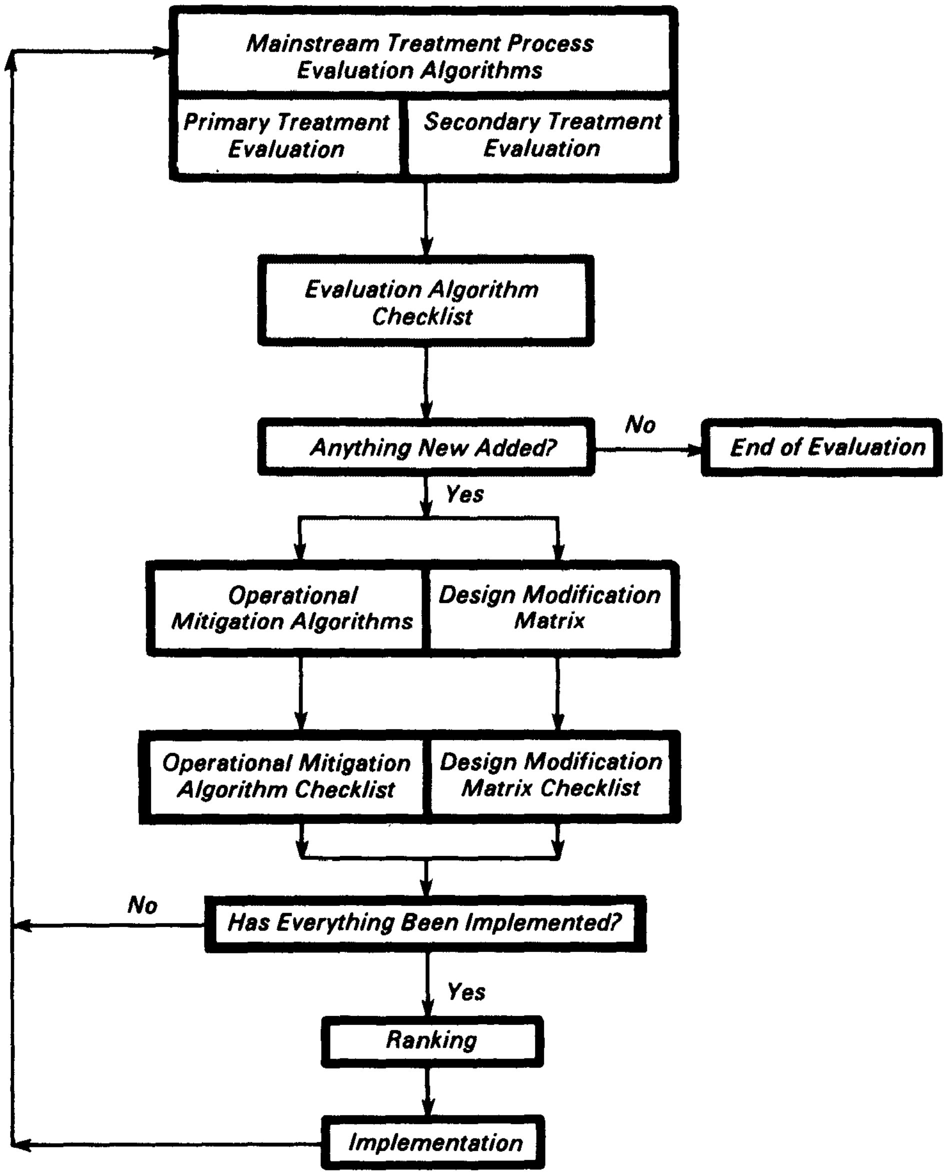

Figure 1. *Summary of the evaluation processes.*

impact, the processes must then be re-evaluated by using the original evaluation algorithm. This time, however, if a problem still exists (and knowing that operational methods have been tried to correct the condition), the user is referenced to design modifications to control the impact.

Methodology

A process matrix was developed to categorize sidestream volumes and strengths typical of various types of POTW's. From this matrix, the impact of the sidestreams on overall POTW performance and effluent quality was determined, and operational evaluation and control procedures and design information to minimize their impact were developed.

The process matrix contains the following mainstream treatment processes and sidestream generators:

Mainstream treatment processess

- Primary clarification-(P)
- Activated sludge-(AS)
- Trickling filter-(TF)
- Rotating biological contactor-(RBC)

Sidestream generator/sidestream

- Gravity thickener-(GT)/supernatant
- Dissolved air flotation-(DAF)/subnatant
- Anaerobic digestion-(AnD)/supernatant
- Aerobic digestion-(AeD)/supernatant (decant)
- Vacuum filter-(VF)/filtrate
- Centrifuge-(C)/centrate
- Belt filter press-(BF)/filtrate
- Sand drying bed-(SB)/under-drainage liquor
- Sludge lagoon-(LA)/supernatant
- Heat treatment-(HT)/liquor
- Wet air oxidation-(WAO)/liquor
- Pressure filter (filter press)-(FP) /filtrate
- Purifax-(PX)/supernatant, filtrate, subnatant, or under-drainage liquor

It was necessary to develop a matrix (Table 1) of typical wastewater treatment processes/sidestreams from which operational strategies and design information could be developed.

The treatment processes and sidestream generator elements of the matrix were selected through a complete prioritization procedure that took into account such factors as numbers in use, the number and type of sidestreams in typical treatment plants, and the sidestream's character. As part of the development of the matrix, data on the character of specific sidestreams were accumulated by means of a literature search; these data were used in mathematical process models to predict the overall impact of sidestreams on typical treatment plants.

Table 2 presents information gathered on sidestream characteristics during the literature search. Table 3 is an example of a summary of sidestream characteristics that have been predicted through the use of mathematical models.

It was necessary to assign priorities to the information to develop a matrix of this type (Table 1) because of the different combinations of processes that can possibly be found in POTW's. As an example, from the matrix shown in Table 1, over 1,300 plant-wide sidestreams are possible with potentially different characteristics. Additionally, if other factors are considered (e.g., separate digestion and/or thickening for primary treatment processes, or thickening before and after digestion), the number of possible sidestreams with potentially different characteristics could grow into the tens of thousands.

Results and Discussion

This project developed the general methodology to assess and control the impact of sidestreams on mainstream processes. The methodology developed in the report is presented in the form of algorithms, similar to logic flow diagrams, which allow this information to be applicable to various site specific situations.

Two types of algorithms were developed - evaluation and control algorithms.

Evaluation algorithms were developed to evaluate mainstream treatment processes primarily with respect to the impact of sidestreams. The mainstream processes that were considered included the primary and secondary treatment processes shown in the matrix in Table 1. Secondary clarification was considered as part of each secondary treatment process. As an

Table 1. *Process Matrix*

	Treatment Process			
Sidestream Generator	*Primary (P)*	*Activated Sludge (AS)*	*Trickling Filter (TF)*	*Rotating Biological Contactor (RBC)*
Gravity thickener (GT)	○	●	●	●
Dissolved air flotation (DAF)	○	●	●	●
Anaerobic digestion (AnD)	●	●	●	●
Aerobic digestion (Aed)	○	●	○	○
Vacuum filter (VF)	●	●	●	●
Centrifuge (C)	●	●	●	●
Belt filter press (BF)	●	●	●	●
Sand drying bed (SB)	●	●	●	●
Lagoon (LA)	○	●	●	●
Heat treatment (HT)	●	●	●	●
Wet air oxidation (WAO)	●	●	●	●
Pressure filter (Filter press, FP)	●	●	●	●
Purifax (PX)	●	●	●	●

○ *No evaluation required. These process combinations were not considered typical for POTW's and, therefore, were not used for plant-wide sidestream predictions and evaluations.*
● *Evaluation required.*

example, Figure 2 illustrates a portion of the algorithm that is used to evaluate the impact of sidestreams on primary clarification.

Control algorithms were developed to be used as guides in making operational changes at the mainstream and sidestream processes to control the impact of the sidestreams. Algorithms were developed for each of the mainstreams and sidestreams shown in the matrix in Table 1.

An example of a control algorithm for gravity thickeners is shown in Figure 3.

In the event that operational modifications are not sufficient to reduce the sidestream impact, design information is presented that will assist in the control of sidestream impacts. An example of design information suggested for a specific sidestream impact is presented in Table 4.

Summary

The full report presents methods to evaluate whether mainstream treatment processes are being impacted by sidestreams occurring within a POTW. In the event that an impact is determined, methods are established to control the impact(s) operationally or, if required, through design modifications.

The methodologies presented in the report for the evaluation and control of sidestreams in POTW's are not intended to represent all of the available means nor are they each intended to apply to all POTW's. The report format, utilizing individual algorithms, is intended to be flexible so that the information can be tailored and applied to each individual POTW.

The full report was submitted in fulfillment of Contract No. 68-03-2775 by Roy F. Weston, Inc., under the sponsorship of the U.S. Environmental Protection Agency.

Table 2. *Sidestream Characteristics, Summary of Literature Review*

Sidestream Generator	*Numbers In Use*[a]	*Solids Retention, %*	*BOD_5, mg/L*	*SS, mg/L*
Gravity thickening	*940*	*80-95*	*100-400*	*98-2,500*
Dissolved air flotation	*314*	*70-99.9*	*50-3,950*	*20-2,440*
Anaerobic digestion	*6,796*	*—*	*2-11,014*	*100-32,400*
Aerobic digestion	*4,750*	*—*	*5-6,350*	*10-41,800*
Vacuum filtration	*1,912*	*80-99.5*	*10-10,000*	*160-20,000*
Centrifugation	*368*	*30-98*	*173-10,000*	*100-20,000*
Belt filter press	*132*	*22-99.8*	*46-146*	*30-3,400*
Sand drying beds	*10,939*	*85-100*	*6-6,000*	*20-800*
Lagoons	*797*	*—*	*150*	*71*
Heat treatment	*170*	*90-99+*	*1,600-15,000*	*50-11,400*
Wet air oxidation	*13*	*90-99+*	*3,000-10,000*	*20-500*
Pressure filter	*157*	*96-100*	*1,000-6,500*	*100-1,926*
Purifax	*69*	*—*	*100-350*	*50-150*

[a] *Source: 1978 Needs Survey Data (Updated), U.S. Environmental Protection Agency.*

Table 3. *Example Summary of Sidestreams Characteristics*

Sidestream	Process Description[a]	Flow, gpm	*Loading, lb/Day: TBOD[b]	*Loading, lb/Day: TSS[c]	Concentration, mg/L: TBOD	Concentration, mg/L: TSS
Vacuum filtration	P + AnD + VF	3,471	7.4	37.9	254	1,310
	P + AS + GT + AnD + VF	5,210	16.9	114	389	2,620
	P + AS + DAF + AnD + VF	4,400	14.9	86.7	406	2,360
	P + AS + DAF + AeD + VF	5,190	34.4	95.7	794	2,210
	P + TF + GT + AnD + VF	3,480	9.1	56.0	314	1,930
	P + TF + DAF + AnD + VF	3,750	10.6	64.9	339	2,080
	P + RBC + GT + AnD + VF	3,660	10.3	62.1	337	2,030
	P + RBC + DAF + AnD + VF	3,780	11.1	66.1	351	2,100
Solid bowl scroll centrifuge	P + SBSC	1,660	46.0	90.1	3,320	6,500
	P + AS + GT + AnD + SBSC	2,500	26.0	146	1,250	7,000
	P + AS + DAF + AnD + SBSC	2,350	17.0	137	867	7,000
	P + AS + DAF + AeD + SBSC	611	6.4	15.3	1,250	3,000
	P + TF + GT + AnD + SBSC	1,210	11.8	65.4	1,170	6,500
	P + TF + DAF + AnD + SBSC	1,410	13.3	76.2	1,140	6,500
	P + RBC + GT + AnD + SBSC	1,320	13.0	71.6	1,180	6,500
	P + RBC + DAF + AnD + SBSC	1,440	14.1	77.9	1,180	6,500
Basket centrifuge	P + BC	184	3.9	7.7	2,570	5,000
	P + AS + GT + AnD + BC	1,720	8.2	25.1	575	1,750
	P + AS + DAF + AnD + BC	1,220	5.8	17.8	570	1,750
	P + AS + DAF + AeD + BC	2,050	6.9	15.4	411	900
	P + TF + GT + AnD + BC	658	3.0	9.3	550	1,700
	P + TF + DAF + AnD + BC	899	4.1	12.7	546	1,700
	P + RBC + GT + AnD + BC	823	3.8	11.7	557	1,700
	P + RBC + DAF + AnD + BC	934	4.3	13.2	556	1,700
Belt filter	P + AnD + BF	5,710	5.9	20.7	124	434
	P + AS + GT + AnD + BF	13,100	17.6	78.9	161	724
	P + AS + DAF + AnD + BF	11,900	15.6	71.4	158	719
	P + AS + DAF + AeD + BF	15,400	40.1	101.5	312	789
	P + TF + GT + AnD + BF	6,630	7.5	33.6	136	608
	P + TF + DAF + AnD + BF	7,750	9.0	40.0	139	618
	P + RBC + GT + AnD + BF	7,050	8.6	36.2	146	616
	P + RBC + DAF + AnD + BF	7,510	9.3	38.9	147	620

[a] *P, primary clarification; AnD, anaerobic digestion; VF, vacuum filter; AS, activated sludge; GT, gravity thickener; DAF, dissolved air flotation; AeD, aerobic digestion; TF, trickling filter; RBC, rotating biological contactor; SBSC, solid bowl scroll centrifuge; BC, basket centrifuge*

[b] *Total biochemical oxygen demand*

[c] *Total suspended solids*

Table 4. Primary Clarifiers Operational Impact

Observed Operational Impact Parameter	Alternative Design Modification(s)	Design Criteria for Modification(s)
Solids loading (TSS)	1. Add conditioning chemicals: • Organic polymer • Inorganic salts (alum, ferric chloride, lime)	1. Provide for 1-5 minutes mixing at 100-200 seconds (flocculation for 15-30 minutes at seconds^{-1}), and a chemical dosage of: • 0-10 milligrams per liter (mg/L) • 0-500 mg/L for salts
	2. Increase clarifier area by clarifier addition	2. Surface overflow rate of less than 1,000 gallons per day per square foot with a hydraulic detention time of 90-120 min
	3. Increase overflow weir length	3. Weir loading rate of less than 10,000 gallons per day per linear foot of weir
Hydraulic loading (Q)	1. Increase clarifier area by clarifier addition	1. Surface overflow rate of less than 1,000 gpd/ft^2 with a hydraulic detention time of 90-120 min
	2. Install variable speed influent pumping to reduce flow variation	2. Continuous influent flow at headworks
Effluent dissolved oxygen concentration (DO)	1. Increase or install grit chamber aeration	1. Standard cubic feet per min of air per linear foot

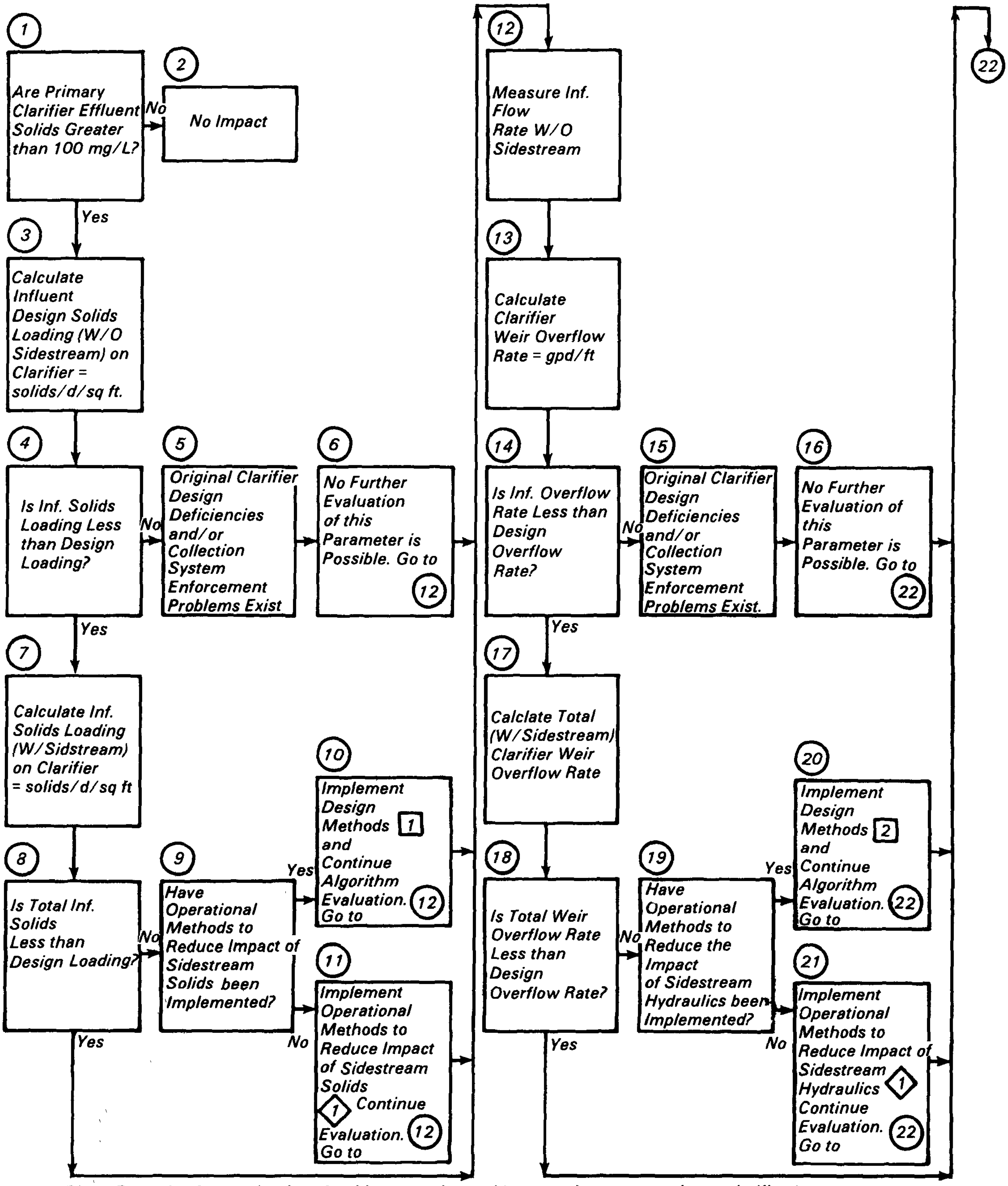

Figure 2. *Example of an evaluation algorithm to evaluate sidestream impacts on primary clarification.*

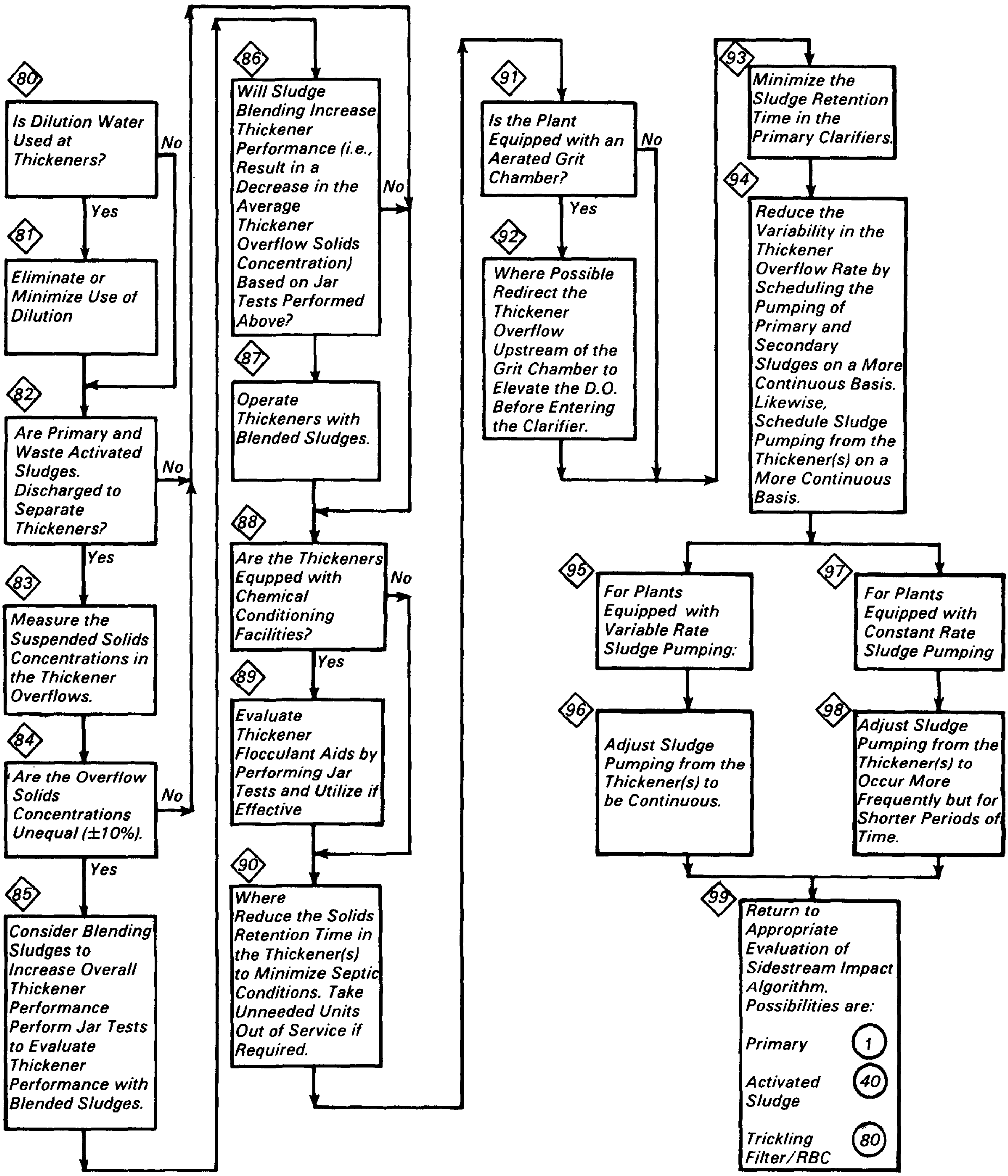

Figure 3. *Example of a control algorithm which outlines operational methods to reduce the impact of gravity thickeners.*

Roy Ball, Michael Harris, and Kevin Deeny are with Roy F. Weston, Inc., West Chester, PA 19380.
***Jon H. Bender** is the EPA Project Officer (see below).*
The complete report, entitled "Evaluation and Control of Sidestreams Generated in Publicly Owned Treatment Works," (Order No. PB 82-195 272; Cost: $18.00, subject to change) will be available only from:
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