

**WASTEWATER REUSE BY IRRIGATION IN HAWAII:
May 1989 Update**

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ABSTRACT

A statewide survey was conducted to determine the nature and extent of wastewater reuse by irrigation in 1989. An average of 13.985 mgd (million gallons/day) of wastewater is applied to 2115+ acres. Acreages are difficult to ascertain because with sugarcane much of the wastewater is highly diluted with other waters and distributed broadly to indeterminable acreages. The 1989 data were compared with an earlier survey conducted in 1977. Current reuse is approximately double the 7.18 mgd recorded in 1977.

The two primary reuses statewide are for sugarcane and golf course irrigation, utilizing 7.382 and 6.288 mgd respectively. Since 3.5 mgd of the effluent applied to sugarcane is utilized irregularly, it is difficult to suggest any trends. Reuse on golf courses, on the other hand, has tripled from the 2.06 mgd in the earlier survey. This increase is attributable to gains on all islands but particularly on Maui.

In the state, there are 24 treatment plant/reuse facilities of which twenty use domestic wastewater and four utilize farm animal wastes.

On an island basis, Maui and O'ahu have the highest wastewater reuse, with 6.185 mgd and 5.072 mgd respectively, followed by Kaua'i (2.09 mgd), Hawai'i (0.528 mgd), and Moloka'i (0.11 mgd).

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INTRODUCTION

The Water Resources Research Center has actively investigated wastewater reuse issues including research since 1971 (Lau et al. 1972, 1974, 1975, 1977, 1978, 1979; Chang and Young 1977; Handley and Ekern 1981; Gee, Murabayashi, and Young 1985). In line with these activities, an initial statewide survey was conducted in 1977 (Lau 1978) to establish the nature and extent of reuse at that time. This report updates and expands on that earlier survey and, for comparison, indicates changes that have occurred.

Every effort was made to identify and contact all known existing wastewater reusers. To the best of the author's knowledge, the listing in Table 1 is a complete cataloging of all reusers as of May 1989. The survey was conducted primarily during August to September 1988 and finalized in May 1989. Some changes occurred even during the survey period. For example, about October 1988, the Makaha Valley Inc. Wastewater Treatment Plant (WWTP), O'ahu, suspended operation when their lines were connected to the Honolulu City and County's Waianae WWTP and consequently ceased effluent irrigation of Makaha's nursery.* Also, Hyatt Regency Waikoloa, Hawaii, became operational in December 1988. Its wastewater is treated together with other makai Waikoloa developments, and is used to irrigate the Waikoloa Beach Golf Club. Effluent reuse levels in May 1989, after the Hyatt came on line, were essentially similar to the amounts reported earlier in August 1988.†

FINDINGS AND DISCUSSION

In the state, there are 24 treatment plant/reuse facilities of which 20 use domestic wastewater and four utilize farm animal wastes (Fig. 1, Table 1). The domestic wastewater is secondary treated, coming primarily from residential sources, with some commercial and possibly a little industrial inclusions. An average of 13.985 mgd (million gallons/day) is applied to 2115+ acres. This quantity of wastewater is not as accurate as the three decimal places imply because flows can vary considerably, particularly by fluctuating hotel occupancy. And some facilities, such as the Lahaina WWTP, periodically conveys all or none of its 3.5 mgd effluent to Pioneer Mill Sugar Company, depending on the Mill's need for irrigation water.‡ Table 1 lists average flow rates, tabulated as received with no rounding.

The 1989 statewide total reuse of 13.985 mgd is approximately double the 7.18 mgd utilized in 1977 (Table 2).

*Manager (Makaha Valley Inc.) 1988: personal communication.

†Ed Hodnett (Golf Course Superintendent, Waikoloa Beach Golf Club) 1989: personal communication.

‡Alex Neri (DPW, County of Maui) 1988: personal communication.

TABLE 1. EFFLUENT REUSE BY IRRIGATION, STATE OF HAWAII, 1989

Site	Island	WWTP Location	Treatment	Avg. Effl. Flow (mgd)	Supplementary Water (mgd)	Dilution Ratio Supp:Effl.	Acres Appld.	Use	Irrigation Rate (mgd/acre)	Ref.
1	Kaua'i	Lihue WWTP	Activated Sludge	0.80	1.2 Fresh	1.50	400	Golf Course	0.005	a
2	Kaua'i	Waimea WWTP	Activated Sludge	0.14	0.16 Fresh	1.10	80	Sugarcane	0.0038	a
3	Kaua'i	Wailua WWTP	Activated Sludge	0.15	0.35 Brackish	2.30	217	Golf Course	0.0023	a
4	Kaua'i	Kiahuna Golf Club	Activated Sludge	0.40	0.13 Fresh	0.33	100	Golf Course	0.0053	b
5	Kaua'i	Princeville Golf Course	Activated Sludge	0.60	0.08 Fresh	0.14	141	Golf Course	0.0048	c
6	O'ahu	Kaneohe Marine Corps Air Sta. WWTP	Trickling Filter	0.50	None	0.00	155	Golf Course	0.0032	d
7	O'ahu	Turtle Bay Hilton (Kuilima Resort)	Oxidation Pond	0.65	0.1	0.15	200	Golf Course	0.0038	e
8	O'ahu	Helemano WWTP	Extended Aeration	0.02	Fresh		*	Sugarcane		f
9	O'ahu	Schofield WWTP	Activated Sludge	2.20	Fresh		*	Sugarcane		f
10	O'ahu	Wahiawa WWTP	Activated Sludge	1.372	Fresh		*	Sugarcane		g
11	O'ahu	Whitmore Village WWTP	Extended Aeration	0.15	Fresh		*	Sugarcane		g
12	O'ahu	Waialea Farm animal waste	None					Pasture		h
13	O'ahu	Universal Synergetics animal wastewater	Anaerobic Digestion	0.017	0.03 Fresh	1.8	†	Greenhouse 0.5 acre in Bananas/Cane		i
14	O'ahu	Waimanalo Dairy	Lagoon	0.163	None		80	Pasture	0.0023	j
15	O'ahu	Omizo Farm (Waimanalo Dairy effluent)			Fresh		3 3 ‡	Banana Corn		k
16	Moloka'i	Kaluakoi Resort		0.11	0.2 Fresh	1.8		Grounds		l
17	Maui	Kihei WWTP		2.50	None	0.0	120	1.0 mgd Golf Course; 1.5 County Park	0.0083	m,n

TABLE 1.—Continued

Site	Island	WWTP Location	Treatment	Avg. Effl. Flow (mgd)	Supplementary Water (mgd)	Dilution Ratio Supp:Effl.	Acres Appld.	Use	Irrigation Rate (mgd/acre)	Ref.
18	Maui	Lahaina WWTP		3.5 [§]	Yes		§	Sugarcane		m
19	Maui	Pukalani Country Club		0.185	0.65 Brackish	3.5	140	Golf Course	0.006	o
20	Hawai'i	Keauhou WWTP	Activated Sludge	0.275	0.9 Brackish	3.3	200	Golf Course	0.006	p,q
21	Hawai'i	Mauna Kea Beach Hotel	Activated Sludge							r,s
22	Hawai'i	Mauna Lani Resort	Aerated Lagoon	0.135	None	0.0	16	Orchard	0.0084	t
23	Hawai'i	Seamountain Golf Course	Activated Sludge	0.018	1.2	66.7	110	Golf Course	0.011	u
24	Hawai'i	Waikoloa Beach Golf Club	Activated Sludge	0.1	1.2	12.0	150	Golf Course	0.0087	v
TOTAL				13.985			2115+			

NOTE: Superscript letters are references.

^aCounty of Kauai, Dept. of Public Works; Questionnaire 8/88.

^bCharles Ortega (Kiahuna Golf Club) 1988: personal communication.

^cYoshi Harada (Princeville Makai and Prince Golf Courses) 1988: personal communication; Questionnaire 9/88.

^dFacilities Dept., Kaneohe Marine Corps Air Station; Questionnaire 8/88.

^eMichael M. Honma, Golf Course Superintendent, Turtle Bay Hilton; Questionnaire 9/88.

^fRudy Mina, U.S. Army Corps of Engineers, Ft. Shafter; Questionnaire 8/88.

^gEarl Ng, Wastewater Div. (Dept. of Public Works, City and County of Honolulu): personal communication; and Questionnaire 8/88.

^hLeonard Fisher (Farm Manager, Waialea Livestock Farm, Univ. of Hawaii) 1988: personal communication.

ⁱJames D. McElvaney (Vice President, Universal Synergetics, Inc.) 1989: personal communication; Questionnaire 4/89.

^jRick Egged (Waimanalo Dairy) 1989: personal communication; Questionnaire 4/89.

^kHerbert Omizo 1988: personal communication; Questionnaire 5/89.

^lNobu Shimizu (Kaluakoi Resort) 1988: personal communication.

^mAlex Neri (Dept. of Public Works, County of Maui) 1988: personal communication.

ⁿSilversword Golf Course; Questionnaire 8/88.

^oPukalani Country Club; Questionnaire 8/88.

^pCounty of Hawaii, Dept. of Public Works; Questionnaire 8/88.

^qGlen Delatore (Keahou-Kona Golf Course) 1988: personal communication.

^rHarold Yee and David Gustafson (Dept. of Health) 1988: personal communication.

^sBob Itamoto (Golf Course Superintendent, Mauna Kea Beach Golf Course) 1988: personal communication.

^tLee G. Carpenter, Mauna Lani WWTP, Inc.; Questionnaire 8/88.

^uPunaluu Water and Sanitation Co.; Questionnaire 8/88.

^vWaikoloa Beach Golf Club; Questionnaire 8/88.

*Effluent flows into Waialua Sugar Co. irrigation water and is distributed widely to undetermined acreages.

†Effluent and supplementary water used for greenhouse; an additional 0.5 acre each of sugarcane and bananas irrigated only with effluent.

‡Undetermined amount of wastewater from Waimanalo Dairy used as supplementary irrigation source only during dry summer months. Of 9 acres of cropland, 3 acres each are in banana and incorn, and rotated so that all 9 acres are not cultivated at one time.

§Pioneer Mill sometimes accepts all and other times nothing of the Lahaina WWTP's 3.5 mgd average daily flow; the effluent mix distributed widely to undetermined acreages.

||Effluent applied to undeveloped area and never to golf course except for short experiment on two holes; but effluent irrigation is planned for the future.

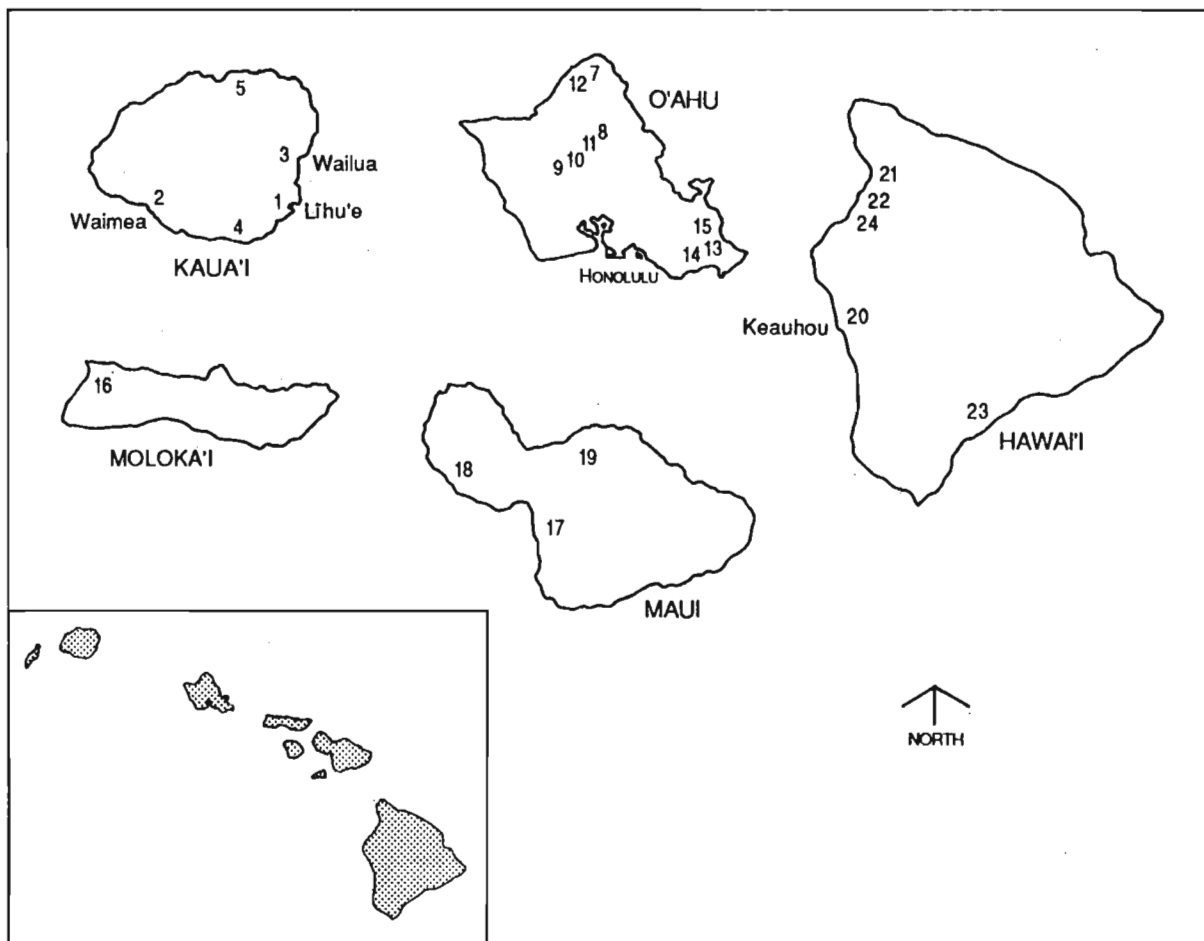


Figure 1. Wastewater Treatment Plant and effluent reuse facility sites, state of Hawai'i

Major Reuses

The two primary reuses are sugarcane utilizing 7.382 mgd, and golf courses with 6.228 mgd, as indicated in Table 2 which also shows effluent quantity and acreage by island. Ancillary grounds are included with golf courses where they are irrigated by the same effluent-management system. Statewide, the acreage for sugarcane is significantly higher than the 80+ acres indicated because on O'ahu the effluent from the Wahiawa and Whitmore WWTPs is first highly diluted in Wahiawa Reservoir, then the reservoir water irrigates extensive but undetermined Waialua Sugar Company acreage. The same is true of the Schofield WWTP and Helemano WWTP effluent which eventually reaches Waialua Sugar fields downstream. Similarly on Maui, the effluent from Lahaina WWTP is extensively distributed but the acreage was not readily determinable.

TABLE 2. EFFLUENT QUANTITY AND ACREAGE, STATE OF HAWAII, 1989, 1977

ISLAND	1989								1977*			
	Sugarcane		Golf Course and Grounds		Orchard/Greenhouse/Pasture		Total		Sugarcane	Golf Course	Other	Total
	(mgd)	(acres)	(mgd)	(acres)	(mgd)	(acres)	(mgd)	(acres)	(mgd)	(mgd)	(mgd)	(mgd)
Kaua'i	0.14	80	1.95	858			2.09	938	0.8			0.8
O'ahu	3.742	†	1.15	355	0.18	87+	5.072	441+	3.67	1.56	0.15	5.38
Moloka'i			0.11				0.11					
Maui	3.5	†	2.685	260+			6.185	260+	0.5	0.5		1.0
Hawai'i			0.393	460	0.135	16	0.528	476				
STATE TOTAL	7.382	80+	6.288	1933	0.315	103+	13.985	2115+	4.97	2.06	0.15	7.18

*Lau (1978, pp. 4, 5).

†Indeterminable acreage.

Sugar companies presently utilizing sewage effluent are Waialua (O'ahu), Pioneer Mill (Maui) and Waimea (Kaua'i). The statewide effluent usage for sugarcane appears to have increased from 4.97 mgd in 1977 to 7.382 mgd in 1989, attributable mainly to Lahaina WWTP (Maui). However, as mentioned earlier, Pioneer Mill does not accept the effluent at all times; hence, the average would be less than 3.5 mgd. No effluent irrigation of sugarcane is practiced on the island of Hawai'i partly because much of the sugarcane lands are unirrigated and also, there are no significant centralized wastewater facilities in proximity to sugarcane fields.

Statewide golf course effluent irrigation tripled from 2.06 mgd in 1977 to 6.228 mgd in 1989 (Table 2). This is due to gains in all islands but particularly on Maui (Kihei WWTP Silversword and Pukalani Country Club), Kaua'i (Wailua WWTP, Princeville golf course, Kiahuna Golf Club, and Lihue WWTP which had switched from irrigation of sugarcane in 1977 to golf course in 1989) and Moloka'i (Kaluakoi Resorts).

On an island basis (Table 2), Maui and O'ahu have the highest reuse with 6.185 mgd and 5.072 mgd respectively, followed by Kaua'i (2.09 mgd), Hawai'i (0.528 mgd) and Moloka'i (0.11 mgd).

Minor Reuses

Relatively little effluent (0.315 mgd) is used to irrigate the miscellaneous category of orchard, greenhouse, and pasture in 1989 although it is double the "other" category of 0.15 mgd in 1977. A 16-acre coconut and citrus grove at Mauna Lani Resort, Hawai'i, is the primary effluent use in this category (Table 1).

Miscellaneous Findings

While nutrient content was included in the questionnaire, insufficient data were received for tabulation.

Regarding difficulties attributable to using effluent for irrigation, the vast majority reported no problems. The one and only difficulty, reported by six respondents, was algae growth, particularly as it related to emitter clogging.

CHANGES SINCE 1977

Effluent from a number of WWTPs listed in 1977 is no longer reused for irrigation. The WWTPs on O'ahu are Hawaii Kai, Church College-Brigham Young University-Hawaii,*

*WWTP operator (BYU) 1988: personal communication.

Makakilo Hts. and Nanakai, where sugarcane is no longer grown in its vicinity, and Makaha Valley Inc. WWTP which ceased operation as mentioned earlier.

On Maui, the private Kaanapali WWTP has been replaced by the Maui County Lahaina WWTP.* On Hawai'i, the Kailua-Kona WWTP disposes all of its effluent through an ocean outfall.†

The only WWTP that has changed its treatment process is Schofield, converting from trickling filter to activated sludge.

TABLE 3. GOLF COURSE IRRIGATION RATE,
STATE OF HAWAII

WWTP/Golf Course	Irrig. Rate ¹ (mgd/acre)
Lihue WWTP	0.005
Wailua WWTP	0.0023
Kiahuna Golf	0.0053
Princeville Golf	0.0048
Kaneohe Klipper Golf	0.0032
Turtle Bay Golf	0.0038
Kihei WWTP	0.0083
Pukalani Golf	0.006
Keahou-Kona Golf	0.006
Seamountain Golf	0.011
Waikoloa Beach Golf	0.0087

Average irrigation rate = 0.006 mgd/acre

¹Includes wastewater and any additional irrigation water applied.

GOLF COURSE IRRIGATION

The information compiled in this reuse survey was used to calculate golf course irrigation rates (Table 3). The volume applied includes both wastewater and any supplementary water. The average irrigation rate is 0.006 mgd/acre with a maximum of 0.011 mgd/acre and minimum of 0.0023 mgd/acre. While the range is relatively wide, it should be remembered that each course is unique, having different soils and climatic conditions which influence evapotranspiration. Also, meager water supplies can limit the amount available for irrigation. Similarly, where brackish water is used, periodic over-irrigation may be needed to leach salts

*Alex Neri (DPW, County of Maui) 1988: personal communication.

†DPW, County of Hawaii 1988: personal communication.

from the root zone. Ultimately of course, there are differing management philosophies among golf course administrators.

By comparison to a typical 150 acre golf course, the 0.006 mgd/acre average irrigation rate given above corresponds to 0.9 mgd total. This is 0.1 mgd (or 10%) less than the 1.0 mgd rule-of-thumb rate customarily used for courses of that size.

In many instances, the quantity of wastewater generated by a resort-hotel is insufficient to meet its golf course irrigation needs. Therefore, as shown in Table 1, much of the effluent is supplemented with additional fresh or brackish water. In effect this greatly dilutes the nutrients contained in the effluent, thereby enhancing the likelihood of substantial, if not complete, uptake of nutrients by the irrigated plants. With their fibrous rooting mat, grasses are particularly efficient in nutrient uptake. Lau et al. (1975, pp. 56, 57) reported high nutrient removal rates from undiluted secondary effluent by bermuda grass sod. In light of the high dilution ratios (Table 1) and nutrient uptake by the plants, the percolate nutrient content would be very low, certainly lower than those reported by Lau. Thus, wastewater irrigation under these conditions would be unlikely to contribute significant amounts of nutrients to the groundwater.

At sites isolated from other urban development, such as resorts on the west coast of Hawai'i where no access to ocean outfalls exists, reusing wastewater for irrigation can accomplish four objectives: (1) the effluent is disposed; (2) the wastewater augments frequently scarce irrigation water; (3) nutrients are recycled by plant uptake; and (4) land treatment reduces nutrient loading of coastal waters.

TRENDS

The major statewide change that has occurred in the 12-yr interim between surveys is the tripling of wastewater reuse for golf course irrigation, from 2.06 mgd in 1977 to 6.228 in 1989 as shown in Table 2. This increase has occurred on every island except O'ahu, with gains predominantly on Maui and Hawai'i. If tourism continues strong, it appears likely that this trend will continue because there are many undeveloped potential resort sites, isolated from consolidating sewerage systems and ocean outfall facilities. Many of these sites have limited freshwater sources, thereby increasing the likelihood of irrigating with wastewater.

As for changes in statewide reuse by sugarcane, Table 2 shows about a 50% increase between 1977 and 1989, from 4.97 mgd to 7.382 mgd which is largely attributable to the 3.5 mgd used infrequently by Pioneer Mill. Since this quantity is not utilized all the time, some

unknown amount should be discounted. It is difficult to suggest any trends, except to note that sugarcane acreages have been declining statewide.

A new aspect noted during the survey is Universal Synergetics' interest in commercial application of animal wastewater irrigation and other reuse technology. In Hawaii, this is the first entrepreneurial recognition of wastewaters potential as a resource to be utilized rather than something to be disposed. They currently operate a greenhouse using wastewater as well as starting experiments in field and horticultural crops.

Copies of the cover letters (App. A.1, A.2) and questionnaire (App. A.3) append this report.

ACKNOWLEDGMENT

The subject of this report was the brainchild of Dr. L. Stephen Lau, Director, Water Resources Research Center. The author gratefully acknowledges his continued support, advice, and review in bringing this report to fruition.

Also to all of you who so graciously responded to the questionnaire and my telephone calls, I could not have done any of this without your much appreciated cooperation.

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APPENDIX A.1. INITIAL LETTER

We are conducting a survey on reuse of sewage effluent for irrigation, of golf courses and sugar cane as examples, and ask your indulgence and cooperation in answering the enclosed questionnaire.

A similar state-wide survey was taken over ten years ago. We are presently updating the data and your input would help immeasurably to accurately portray the current status of the reuse of this resource in Hawaii.

Thank you for your help. If you have any questions, my number is (808) 948-8008.

Sincerely,

Edwin T. Murabayashi
Researcher Associate

ETM: jm

Encl.



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APPENDIX A.2. FOLLOW-UP LETTER

SUBJECT: Survey on reuse of sewage effluent for irrigation

A few weeks ago, I had sent a questionnaire to survey the reuse of treated sewage effluent for irrigation. Inasmuch as the reply has not been received as yet, I am again asking your indulgence and cooperation in returning the questionnaire. If you have already done so, please pardon this intrusion. We really value and need your input in order to accurately depict the current status of the reuse of this resource.

In case the earlier questionnaire has been mislaid, I am enclosing another. The primary interest is in the quantity of effluent used (question No. 2). It is not necessary to complete the whole questionnaire if the information is unavailable.

Thank you again for your help. If you have any questions, my number is (808) 948-8008.

Sincerely,

Edwin T. Murabayashi
Research Associate

ETM:jm

SEWAGE EFFLUENT REUSE QUESTIONNAIRE

1. Name of golf course or firm: _____
2. Amount of sewage effluent used in irrigation:

Higher amount _____ during _____

gallons/day months or season

Lower amount _____ during _____

gallons/day months or season

Average amount _____ during all year around.

gallons/day
3. Is supplementary water used to meet irrigation requirements? _____

yes/no

Amount used _____

Type of water _____

fresh, brackish, etc.

Mixed with effluent _____

yes/no
4. What is done with any excess effluent beyond that needed for irrigation?
5. Do you have any difficulties associated with using effluent for irrigation? Are they mild or serious problems and what are they?
6. Type of sewage treatment plant _____

trickling filter, activated sludge, etc.
7. If you have the figures:
 - a) Area that is irrigated with water containing effluent _____.
 - acres
 - b) Total area that is irrigated _____.
 - acres
 - c) Total nitrogen in effluent _____.
 - milligrams/liter
 - d) Total phosphorus in effluent _____.
 - milligrams/liter
8. Any other comments.