RECYCLING MUNICIPAL EFFLUENT USING ALFALFA TO PRODUCE A PROFIT

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ABSTRACT

Irrigation water is in short supply in many areas of the State, energy costs are escalating to the point that many growers cannot continue in business, and more environmental concerns are being raised regarding the disposal of wastewater. Using recycled water to irrigate alfalfa helps solve these problems. In this way, a waste is transformed into a valuable resource that can be used to produce a profit for the grower and an asset for society.

Nebeker Ranch has used reclaimed wastewater for fourteen years to produce premium alfalfa hay to receive top dollar from the market place. Our experiences are shared in this paper in hopes of debunking misinformation regarding this practice, pointing out pitfalls and making recommendations to assist other growers to identify the problems and potential of using municipal effluent to irrigate alfalfa.

Key Words: recycling, alfalfa, municipal wastewater, management, irrigation

INTRODUCTION

Almost everyone in agriculture is aware that water for irrigation is becoming in short supply in many areas of California. The federal Central Valley Project and State Water Project have recently warned of further cuts (Kranz 2001). Energy costs to pump water have risen as much as 50% for some growers during 2001. As these resources become scarce and more valuable, municipal effluent for irrigation becomes more attractive.

Environmental concerns regarding the disposal of wastewater are increasing. Canneries, dairies, food processors and other industry as well as municipal treatment plants are looking to growers for the disposal and productive utilization of this water. Transforming nitrogen in the water to plant protein may be the most environmentally safe way and most cost effective method to utilize this water.

The State Water Resources Control Board website was surveyed for recycling projects that use alfalfa to dispose and utilize municipal wastewater. The number of farming operations in the State which utilize this water to produce top quality alfalfa hay in a serious and cost effective manner are rare. Most of these operations focus on effluent disposal to the detriment of the farming needs.

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BACKGROUND

Nebeker Ranch is a 680 acre alfalfa ranch in the Antelope Valley region (High-Desert) of Los Angeles County. The area has a reputation for high-quality alfalfa hay. Nebeker Ranch supplies only premium horse and dairy hay (Nebeker 1991). Historically, ground water has been used to irrigate alfalfa since 1919 (82 years). Fourteen years ago, the principal source of irrigation water became municipal effluent.

As shown in Figure 1, the source of this water is the Lancaster Water Reclamation Plant (Plant) owned and operated by the County Sanitation District No. 14 of Los Angeles County (District). More details of this relationship between Nebeker Ranch, Inc. and the District are given in Lambert and Nebeker 1996. This plant treats the municipal wastewater from Lancaster and parts of Palmdale to the secondary level for our operation. A 24-inch diameter pipeline, 6.8 miles in length, was installed from the Plant to Nebeker Ranch. Nebeker Ranch, Inc. pays for the cost of pumping water to the ranch from a pumping station, using two 150 HP pumps. As part of this project, 160 acres of reservoirs were constructed to store water that would have to be disposed of during the winter. A small amount of water from this plant is treated to the tertiary level and provides water to recreational lakes at Apollo Park.

Most of the water that is not used at the ranch is diverted to Piute Ponds, which is a wetland area used by many birds and other wildlife. Unfortunately, do to the significant population growth, the plant effluent management capacity has been exceeded. As a result, so much water flows to Piute ponds that its capacity is exceeded and parts of Rosamond Dry Lake are flooded during portions of the year. Edwards Air Force Base uses this lakebed for certain types of testing and to recover aircraft with in-flight emergencies. Also, the likelihood of bird strikes on aircraft becomes greater when water is on the lakebed. Water on the lakebed increases the risks of damage to costly aircraft and possible loss of life.

From an agricultural perspective, an advantage of this arrangement is that the Ranch only takes water from the Plant when it is needed for irrigation.

BENEFITS

Nebeker Ranch, Inc. This alfalfa farming operation saves on the costs of operating and maintaining ground water wells and pumps, saves on the reduced energy costs of moving effluent from the Plant to the ranch as compared to pumping groundwater, and saves on fertilizer costs (both nitrogen and phosphorous). At the present time, about $80,000 is saved on electrical energy and $25,000 on fertilizer costs per year.

Edwards Air Force Base. Keeping effluent water off Rosamond Dry Lake by irrigating alfalfa at Nebeker Ranch is considered to have national defense significance. Approximately 1 billion gallons (4000 acre-feet) per year are kept off the Dry Lake by this practice. Since the project started 14 years ago, about 10 billion gallons have been prevented from flowing to this Dry Lake bed.

Districts. Irrigation of alfalfa by secondary effluent has saved the District $165,000 to $1,000,000 per year in avoided treatment and disposal costs, depending on the alternate disposal option.

Community. In additional to the benefits received by Edwards Air Force Base and the District, about 4000 acre-feet or 1 billion gallons of water per year (or 10 billion gallons since this project began) has been allowed to remain in the groundwater basin for the public to enjoy. At a water replacement cost of $200 per acre-foot per year, this savings in potable water can be estimated at $800,000 annually. Also, this large volume of effluent has been disposed of in an environmentally safe way.

Although Nebeker Ranch benefits from this relationship, the benefits to the other parties in this may be an order of magnitude greater. Everybody wins.

WHAT DOES A WATER RECLAMATION PLANT DO?

The Plant is designed to accept 16 million gallons per day (mgd) of municipal wastewater (raw sewage). The current average daily flow is slightly more than 12 mgd. The treatment process is illustrated in Figure 2.

Raw sewage entering the plant is 99.9% water. The larger solids in the influent wastewater are ground by a comminutor. The water then is passed through a grit chamber where diffused air bubbles up to suspend any organic material. Eggshells and inorganic material such as sand, grit, etc. are allowed to settle out.

The water then flows into large primary settling tanks that slow the flow rate so the heavy organic materials settle out and the other organics float to the top. Both floating and settling organics are removed and sent to digesters. The digesters operate at 96 to 98 °F that allows bacteria to digest most of the organic material. The residual, which is not digested, is referred to as sludge or biosolids. This process completes the primary treatment of the water.

For secondary treatment, the primary effluent passes into oxidation ponds that resemble reservoirs. The purpose of these ponds is to biologically oxidize organic compounds to carbon dioxide and water using bacteria with the help of oxygen in the air. After a residence time in the treatment Plant of 60 to 90 days, the water is pumped to our ranch for irrigation.

The secondary effluent that is not used at our ranch is discharged to Piute Ponds for a wildlife habitat. This effluent is disinfected because of body contact by Air Force personnel who use this area for duck hunting. A small amount of water not sent to Piute Ponds or Nebeker Ranch goes through a tertiary process for a recreational lake. The tertiary process consists of a prechlorination stage to breakdown the algae, followed by an alum (aluminum sulfate) treatment that makes the algae settle out and to precipitate out the phosphate in the effluent. Then the water is filtered by a gravity multimedia filter consisting of various sizes of sand and rock and by anthracite coal. Finally, the water is chlorinated for disinfection.

The costs of treatment are substantial and the economics of using recycled water should be considered before planning a reuse or recycling operation. In Antelope Valley, the energy cost to pump potable water from the ground is about $50 per acre-foot. The costs of primary and secondary treatment of wastewater are about $250 per acre-foot. Tertiary treatment alone costs about an additional $250 per acre-foot. Therefore, wastewater treatment to the tertiary level costs the treatment plant about ten times the current cost to pump groundwater. These costs are only approximate and vary according the specific conditions of each treatment plant.

WHAT IS SECONDARY EFFLUENT?

Secondary treatment processes are designed to reduce levels of suspended solids, biological and chemical constituents, and pathogenic organisms (organisms that may cause disease in humans). Nitrogen species, chloride, phosphorous species, some metals, and some bacteria and viruses are commonly found in secondary effluent.

The water quality of any secondary effluent will depend upon the municipal water supply. The undisinfected secondary effluent used at Nebeker Ranch has the average characteristics shown in Table 1. The water quality is significantly better than the limits specified by the State of California Water Quality Control Boards. The heavy metals are often below the concentrations required for drinking water. Sewage from industry undergoes pretreatment to remove heavy metals before the water enters the waste stream. In addition, the treatment process at the wastewater treatment site removes additional metals.

Table 2 compares the quality of this secondary effluent to water quality guidelines recommended for irrigation water. This effluent has been used at the Ranch for fourteen years without problems.

The undisinfected secondary effluent contains various microorganisms that may be pathogenic to humans (i.e., cause disease). These may consist of bacteria, viruses, helminthes and protozoa. The State of California Department of Health Services considers this water to be safe for irrigators to use and to be in contact with animal feed and fodder crops.

The total coliform bacteria count is traditionally used as an indicator of the amount of all these organisms that might be present. Pathogenic organisms are in extremely small concentrations relative to coliforms. The total coliform count for secondary effluent is roughly equivalent to that which is naturally present in lakes and streams. Also, this count for secondary effluent is less than that used to initiate the closing of beaches to swimmers.

Nearly all of these pathogenic organisms of human body origin cannot reproduce outside the body and either die or are consumed by microorganisms that live in the environment. For instance, the Centers for Disease Control stated that HIV cannot be transmitted by means of raw sewage (unless the sewage is directly injected into the bloodstream). HIV is devastating when in the bloodstream, but is extremely fragile outside the human body and dies off rapidly in the sewer system, usually within 12 hours. Furthermore, helminthes are not even a concern in countries that have highly developed sanitary systems, and the protozoan *Cryptosporidium* has not even been detected in raw wastewater in Los Angeles County.

We recommend to our employees that they wash their hands before eating and after they come in contact with the effluent. With reasonable personal hygiene such as this, our employees as well as employees of wastewater treatment plants have demonstrated no greater incidence of disease than the normal population.

FATE AND EFFECTS OF CONSTITUENTS OF CONCERN

As indicated above, nitrogen species, chloride, phosphorous species, salts, some metals, and some microorganisms such as bacteria and viruses are often found in secondary effluent. Phosphorous is usually not a threat to groundwater because it is retained in surface and subsurface soils by chemical changes and adsorption. Microorganisms and metals are filtered out in the top few inches of the soil.

The nitrogen species are readily converted to nitrate, which is very soluble in the water. Chloride and salts are also very soluble and travel with the water into the soil. The amount of salt in the effluent is similar to the amount in the groundwater in our area so this salt is leached below the root zone similar to most agricultural operations. Chloride is also not a concern because the amount that can be assimilated by the groundwater without causing a problem is very large. Nitrate is the "contaminant" in the effluent that we must manage judiciously. High concentrations of nitrates in potable water supplies have been found to cause methoglobinemia or "blue baby syndrome."

Recent soil tests at Nebeker Ranch for nitrate, phosphate, and heavy metals have confirmed many of these behaviors. Phosphate is confined to the upper foot of soil. Heavy metal concentrations are at the same level (background) as those at raw land in the vicinity of the ranch. Nitrate and phosphate concentrations are high at the soil surface, but become very low at a depth of only three feet.

WHY IS ALFALFA AN EXCELLENT CROP TO GROW WITH EFFLUENT?

Effluent Can Be Disposed in a Beneficial, Productive Manner. As discussed above, effluent can be disposed of to produce a crop that has a reasonable market value.

Large Volumes of Water Can Be Disposed. As illustrated in Table 3, alfalfa in our area can dispose of 7 ½ feet of water per year. This amount is usually greater than most other crops. Care must be taken to not over-irrigate because alfalfa is very sensitive to too much water in the root zone.

Nitrogen Needs Are Large. Table 4 demonstrates that alfalfa consumes relatively large amounts of nitrogen in every ton of yield (65 lbs. of nitrogen per ton of yield). Also, since the total yield of alfalfa is high, the total nitrogen requirements are great. For instance, if our yield is 8 tons per acre, the nitrogen needs are 520 pounds per acre per year.

Nitrogen Scavenging Ability of the Roots. The literature indicates the alfalfa roots are excellent scavengers of nitrogen. Since alfalfa expends less energy to take up nitrogen in the effluent, it will do so first, and then when supplies are depleted, it will use soil rhizobium bacteria to produce nitrogen in its nodules.

Low Level of Treatment. Alfalfa is a real cost saver to the wastewater treatment plant. Since alfalfa can accept undisinfected secondary effluent. The costs of disinfection and tertiary treatment are avoided.

Market is Relatively Stable and Reliable. The alfalfa market is not subject to the extreme swings of the market for other crops. Therefore, the profitability of an alfalfa operation can be predicted with more certainty.

Wildlife Habitat. The perennial nature of alfalfa fields promotes habitat for birds. Eighty-two bird species have been observed at our ranch (San Miguel 2001)

VALUE OF SECONDARY EFFLUENT TO AN ALFALFA FARMING OPERATION

Source of Irrigation Water. With decreasing water availability to growers in many areas of the State, this attribute may be very important.

Reduced Pumping Costs. As energy costs continue to soar upward, this benefit may allow the grower to survive.

Fertilizer. Secondary effluent should have more than enough phosphorous to supply the needs of alfalfa. Each of our irrigations furnishes about 17 lbs. of phosphate. For our twelve annual irrigations, about 200 lbs. of phosphate are applied per acre per year. Each irrigation provides about 23 lbs. of nitrogen. While using a grain crop in a rotation with alfalfa, we need to be aware of the amount of nitrogen in the effluent and to irrigate often enough to provide the nitrogen needs of the grain. Five irrigations are needed to give the grains their requirement of 100 lbs. of nitrogen per acre per year.

Stable Source of Water. A wastewater treatment agency needs to get rid of water every day. This necessity usually results in the stable source of water for the grower.

CULTURAL COMPLEXITIES IN USING EFFLUENT

Many growers and University of California Extension specialists feel that using effluent requires a higher level of management than using water from more traditional sources. Our experiences are consistent with this perception. In particular, we have considered:

Increased Alfalfa Stand Establishment Costs. Our experiences and those of other growers indicate some difficulties are experienced when using effluent water to germinate and establish an alfalfa stand. To avoid these problems, we use groundwater to establish a stand.

Increased Weed Problems During Life of the Stand. Since using effluent means that the fields are fertilized with nitrogen during every irrigation. Therefore, weed control is more of a problem than using groundwater. Weeds that have been most troublesome are Rescuegrass, Bermudagrass, Johnsongrass, Common Purslane, Cheeseweed or Malva, Buckhorn Plantain, and Field Bindweed.

Early Bloom Problems. During the summer months, the alfalfa cuttings seem to bloom earlier. We have modified our market to accept and appreciate this factor.

Mosquito Problems. We keep "mosquito fish" or *Gambusia affinis* in our tailwater ponds and reservoirs to keep the mosquito problem in check.

Drainage. We have laser leveled all our fields and provide special tailwater return and recovery systems.

Particulate and Long Strings of Algae. The secondary effluent is sometimes delivered to us with particulate matter and long strings of algae. Our irrigation valves are designed with large enough openings to pass this material.

Regulatory Concerns. Our irrigators are trained in the regulatory requirements and know how to respond to problems.

REGULATORY REQUIREMENTS

The California Water Code authorizes the California Regional Water Quality Control Boards (Regional Boards) to regulate any discharge of waste that could affect the quality of the waters of the State, both ground and surface. Even though secondary effluent is a valuable resource, the use of reclaimed wastewater constitutes such a discharge. A Regional Board will normally issue permits, termed waste discharge requirements and reclamation requirements, to both the agency treating the treated waste water and the grower, respectively.

The waste discharge requirements issued to the agency supplying the wastewater will specify the minimum quality of the treated effluent that can be supplied to the irrigator. These requirements will be based on the proposed use of the effluent. Many of the requirements have been established by the California Department of Health Services and are implemented through the waste discharge requirements. This permit will also require the agency to sample the effluent on regular intervals and to report the results to the Regional Board. The reports are public record and provide assurance to both the grower and the public that the irrigation water has been treated to the appropriate level.

Reclamation requirements are issued to the grower using the treated effluent. These requirements are tailored to the nature of the proposed use. The grower will need to advise the Regional Board in a reclamation report as to the type of crop to be irrigated, type of irrigation method to be used, nature of the site conditions (soil types, depth to groundwater, proximity to surface waters and flood zones, etc.). Typical reclamation requirements may specify: that signs be posted around the farm to indicate reclaimed water is used; that irrigation water be maintained on site; that buffer zones be established between irrigation areas and streams, flood zones, wells, etc.; and that the use be limited to agronomic nutrient needs. Further, the reclamation requirements will prohibit the creation of a pollution of waters of the state or nuisance conditions. (Pollution is defined as the alteration of the quality of waters to a degree that unreasonably affects the waters for beneficial uses. Nuisance is defined as something that is injurious to health or is indecent or offensive to the senses so as to interfere with the comfortable enjoyment of life or property, affects an entire community and occurs as a result of disposal of waste.) A grower may be required to perform visual observations of the fields to detect violation of reclamation requirements and to install and regularly sample monitoring wells. Additionally, a grower may be required to maintain records and submit reports on the visual observations and results of well sampling, the areas irrigated, type of crop grown, and disposition of the crop, and the amount of water used. Finally, the grower may be charged an annual fee for the reclamation requirements and may be visited by a Regional Board staff member periodically.

The grower is responsible to comply with the reclamation requirements. Any violations of recycled water use permits are subject to enforcement action pursuant to the California Water Code. Enforcement actions normally taken by the Regional Board can vary from verbal notices, formal written notices of noncompliance, cleanup and abatement orders, and cease and desist orders. Violation of cleanup and abatement orders are subject to monetary penalties. These penalties can be substantial and could be a high as $25,000 per day of each violation.

ADDITIONAL CONCERNS OF SOME GROWERS

Fear of Product Resistance in the Marketplace. Many growers are concerned that the use of effluent will detract from or stigmatize their product. We keep "Sewage Disposal Area, Keep Out" signs prominently displayed around the Ranch. However, we will soon change these signs to conform to current regulatory requirements which specify more positive language such as "Recycled Water Used for Irrigation" and "Conservation of Natural Resources," etc. In the fourteen years we have been using effluent, we have never experienced market resistance due to use of effluent. In fact, our hay usually receives a premium in the marketplace.

Pathogens in Water. As mentioned earlier, the level of microorganism that can cause disease in humans is about what one would expect in natural lakes or streams. Our employees as well as treatment plant operators have about the same incidence of illness as the general population.

Odor. Secondary effluent has no noticeable odor at a distance of a few feet from the water. At a close distance, the odor roughly resembles the odor of alfalfa itself. However, if the pipeline that supplies the Ranch is shut off for a few days, the anaerobic processes in the pipeline will result in a disagreeable odor for a few hours until the pipeline is flushed

Public Relations Problems. Although growers are concerned about potential problems from the public, our problems have been non-existent.

LIABILITY IN USING UNDISINFECTED EFFLUENT

Public. In our litigious society, anyone can sue anybody. We stay within the specifications of our Reclamation Permit and use common sense in our operation. We have not had any problems.

Employees. Employees should be aware of the requirements of the Reclamation Permit. They should also be instructed about proper hygiene in handling the effluent.

Government Regulations. As discussed earlier, the Reclamation Permit requirements should be closely followed.

POTENTIAL PROFIT

The value of reclaimed water to an alfalfa production operation is very site-specific and can be estimated by considering:

Value of Effluent Water for Irrigation
Value of Fertilizer in Effluent Water
Value of Energy Savings from not Pumping Groundwater

Less:
- Cost of Connecting Irrigation System to Treatment Plant
- Fear of Product Resistance in Marketplace
- Increased Weed Problems
- Increased Stand Establishment Complexities
  - Alfalfa Germination Problems
  - Weed Problems
- Early Bloom Problems
- Mosquito Problems
- Liability Concerns
- Regional Board Regulation Considerations
- Public Relations Considerations

If the grower can deal with the concerns listed above, the value of the water, energy savings, and fertilizer to his operation can be significant.

SUGGESTIONS FOR A VIABLE EFFLUENT RECYCLING PROGRAM

Below are some factors that a grower may find useful in a program that uses secondary effluent to grow alfalfa:

Soils. Identification of the soil types, soil chemistry, the water-holding capacity, water infiltration rate, and soil profile is important. Our soils are sandy loam at the surface and are comprised of 35 to 40 layers of various soil types from the surface to groundwater. Since water has difficulty moving through different soil types, these layers of soil provide added insurance that nitrogen will not contaminate the groundwater.

Irrigation System Design. The irrigation system should be efficient and effective in providing the required amount of water to the plants at the proper time. With nitrogen-containing effluent, using no more water than is needed is important. The "on-off" nature of the irrigation cycle together with a high efficiency will help protect groundwater and surface water from nitrogen contamination. Since pathogenic organisms may be present in the effluent, the irrigation system should not broadcast effluent in the air outside of the fields. We flood irrigate by the border/check method every week to ten days. Our fields have been laser leveled to provide an average irrigation efficiency of 80%.

Nitrogen Balance. Only enough effluent should be supplied to furnish the agronomic nitrogen requirements of the plant. Since the amount of nitrogen uptake by alfalfa depends on the yield, the grower is required to consistently attain satisfactory yields to use up the nitrogen furnished by the effluent. The nitrogen supplied by the effluent pumped to our ranch provides about one-half of the nitrogen required by our alfalfa plants at our average production level. When we use grain as a rotation crop, the grain should be irrigated at least five times with effluent during the growing season to provide the nitrogen needs of the grain.

Groundwater Monitoring. Groundwater monitoring wells should be installed and sampled periodically to assure the public that the water quality is being protected.

Weed Control Program. Using effluent will provide new weed management challenges to the grower and the grower should be prepared to deal with them.

Disposal of Winter Water. The wastewater management agency that collects and treats the raw sewage needs to dispose of effluent every day. Arrangements should be made to store or otherwise utilize the effluent during the winter months when irrigation water is not needed.

Stable Relationship with the Wastewater Management Agency that Collects and Treats the Effluent. The commitments that an alfalfa grower must make means that this relationship must be good and long-lasting. Our relationship with the District has been cooperative and mutually beneficial for over 20 years.

CONCLUSIONS AND RECOMMENDATIONS

As explained above, effluent may be a tremendous asset to the grower, if the proper preparations are taken to deal with the added complexities. To promote the more widespread use of this resource, the following efforts should be implemented.

Education Program. A program discussing the attributes and problems of using recycled water would be useful in having more growers accept this practice.

Debunk and Dispel Myths and Misinformation. A great deal of misinformation is associated with the use of recycled water in the minds of many growers. A program to explain and dispel these myths would be useful.

Manual of Practice. This manual should more fully discuss and analyze the subjects mentioned above. If someone desires to use wastewater for irrigation, detailed information should be available to guide their efforts.

Table 1
Effluent Quality and Water Reclamation Requirements
Lancaster WRP

CONSTITUENT (UNITS)	AVERAGE EFFLUENT QUALITY[1] FOR 1992	MAXIMUM LIMIT[2]
	Lancaster WRP Secondary	
Total Dissolved Solids (mg/L)	561	1,000
Chloride (mg/L)	126	300
Sulfate (mg/L)	105	450
Coliform Group (MPN/100 ml)	<2	2.2
Nitrite + Nitrate (mg/L)	1.8	10
Turbidity (NTU)	NM	2
pH (pH units)	8.1	6.0 - 9.0
Arsenic (mg/L)	0.004	0.05
Barium	0.02	1.0
Cadmium (mg/L)	<0.005	0.010
Total Chromium (mg/L)	<0.02	0.05
Copper (mg/L)	<0.02	1.0
Lead (mg/L)	<0.04	0.05
Mercury (mg/L)	<0.0001	0.002
Selenium (mg/L)	<0.001	0.01
Silver (mg/L)	<0.005	0.05
Zinc (mg/L)	0.07	5.0
Fluoride (mg/L)	0.44	1.6
Total Identifiable Chlorinated Hydrocarbon (µg/L)	0.02	NS
Phenols (mg/L)	0.006	1.0

1 *Arithmetic mean of effluent analytical data (CSDLAC, Annual Monitoring Report for 1992, 15 March 1993). Frequency of analyses varies among constitutions; frequency specified in the Monitoring and Reporting Programs outlined in RWQCB Order No. 93-75.*

2 *Reclaimed water limitations specified in RWQCB Order No. 89-32 Title 22, Division 4, Chapter 15, "Domestic Water Quality and Monitoring" (1989).*

NS: Not specified
mg/L Milligrams per liter
MPN/100 ml: Most probable number per 100 milliliters
NTU: Nephelometric turbidity units
PC:/L: Picocuries per liter
µg/L: Micrograms per liter
NM: Not Monitored

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Table 1
Effluent Quality and Water Reclamation Requirements
Lancaster WRP

CONSTITUENT (UNITS)	AVERAGE SECONDARY EFFLUENT QUALITY FOR 2000[1]	LAHONTAN RWQCB LIMIT[2]
Total Dissolved Solids (mg/L)	511	NA
Chloride (mg/L)	114	NA
Sulfate (mg/L)	72	NA
Coliform (MPN/100 ml)	1	NA
Nitrite + Nitrate as N (mg/L)	2.28	NA
Turbidity (NTU)	NM	NA
pH (pH units)	8.30	6.0 - 9.0
Arsenic (mg/L)	0.005	NA
Barium	0.07	NA
Cadmium (mg/L)	0.002	NA
Total Chromium (mg/L)	0.01	NA
Copper (mg/L)	0.06	NA
Fluoride (mg/L)	0.42	NA
Lead (mg/L)	0.01	NA
Mercury (mg/L)	0.0002	NA
Selenium (mg/L)	0.001	NA
Silver (mg/L)	0.01	NA
Zinc (mg/L)	0.26	NA
Total Identifiable Chlorinated Hydrocarbon (µg/L)	ND	NS
Phenols (mg/L)	0.006	NA

1 *Arithmetic mean of effluent analytical data (CSDLAC, Annual Monitoring Report for 2000, 29 March 2001). Frequency of analyses varies among constitutions; frequency specified in the Monitoring and Reporting Programs outlined in RWQCB Order No. 93-75A2.*

2 *Limits as per Lancaster WRP WDR Permit No. 6-93-75, secondary effluent.*

NS: Not specified
mg/L Milligrams per liter
MPN/100 ml: Most probable number per 100 milliliters
NA: Not applicable
ND: Not detected
µg/L: Micrograms per liter
NM: Not Monitored

Table 2
Comparison of Effluent Water Quality to Irrigation Water Quality Standard Guidelines[1]

WATER QUALITY PARAMETER	RELATED CONSTITUENTS	UNITS	WATER QUALITY GUIDELINES			EFFLUENT[2] QUALITY
			No Problems	Increasing Problems	Severe Problems	Lancaster WRP
Salinity[2]	Electro conductivity	umho/cm	750	750-3,000	3,000	1038
Permeability	Electro conductivity Adjusted SAR[3]	umho/cm Ratio	500 6.0	500-200 6.0-9.0	200 9.0	1038 (5)
Specific Ion Toxicity	Sodium (by adj. SAR) Chloride Boron	Ratio mg/l mg/l	3 142 0.5	3.0-9.0 142-355 0.6-2.0	9.0 355 2.0-10	(5) 126 0.65
Specific Ion Toxicity from Foliar Absorption	Sodium Chloride	mg/l mg/l	69 106	69 106	— —	139 126
Miscellaneous	Ammonia & Nitrate N.[4] Bicarbonate, HCO_3 pH	mg/l mg/l pH	5 90 6.5-8.4	5-30 90-520 low or high	30 502 —	7.6 (5) 8.1

1 *Adapted from R.S. Ayres and D.W. Westcott, "Water Quality for Agriculture, Irrigation and Drainage Paper 29." FAO, Rome, 1976.*

2 *Plants vary in tolerance to salinity.*

3 *Adjusted Sodium Absorption Ration (SAR) is calculated to include the added effects of precipitation or dissolution of calcium and magnesium in soil and is related to CO_3 and HCO_3 concentrations.*

4 *For sensitive crops.*

5 *Not available.*

6 *Secondary treated water.*

Table 3
Alfalfa Irrigation Schedule

MONTH	EVAPOTRANS-PIRATION RATE (ETo**) FOR LANCASTER (in/ac/mo)	ALFALFA EVPOTRANS-PIRATION RATE (Etalf=0.95*ETo) (in/ac/mo)	ALFALFA WATER REQUIREMENT IRRIGATION AT 75% EFFICIENCY (ac-ft/ac/mo)	IRRIGATION RATE 616 ACRES OF ALFALFA IRRIGATED AT 75% EFFICIENCY (ac-ft/mo)
JAN.	2.14	2.03	0.23	0.0
FEB.	2.98	2.83	0.31	96.9
MAR.	4.64	4.41	0.49	301.7
APR.	5.91	5.61	0.62	384.3
MAY	8.54	8.11	0.90	555.3
JUN.	9.69	9.21	1.02	630.1
JUL.	10.98	10.43	1.16	713.9
AUG.	9.76	9.27	1.03	634.6
SEP.	7.32	6.95	0.77	476.0
OCT.	4.64	4.41	0.49	301.7
NOV.	2.78	2.64	0.29	90.4
DEC.	1.71	1.62	0.18	0.0
TOTAL	**71.09**	**67.54**	**7.50**	**4,184.8**

*** Source: Goldhamer and Snyder, Irrigation Scheduling*

Table 4
Typical Uptake of Nitrogen By Selected Field Crops

CROP	COMPONENT	TYPICAL YIELD (ton/acre)	NITROGEN REMOVAL (lb/ton of yield)	NITROGEN REMOVAL (lb/acre)
ALFALFA	Hay	5.80	65	377
BARLEY	Grain	2.00	42	84
	Straw	2.50	17	43
BEANS, DRY CORN	Beans	1.34	78	105
	Grain	4.50	33	149
	Silage	25.00	9	225
	Stover	2.00	21	42
COTTON	Seed	0.85	79	67
	Stalks	0.63	115	72
OATS	Grain	1.34	42	56
RICE	Grain	3.30	31	102
	Straw	3.50	10	35
SAFFLOWER	Grain	1.34	69	92
SORGHUM	Grain	2.00	42	84
	Stover	1.80	21	38
SOYBEANS	Grain	1.25	134	168
	Stover	1.25	46	58
SUGAR BEETS	Beets	30.00	4	120
	Tops	30.00	4	120
WHEAT	Grain	2.00	39	78
	Straw	3.50	18	63
MIXED GRASS	Hay	2.00	47	94
IRRIGATED PASTURE		2.00	34	68

Source: California Regional Water Quality Control Board Report No. 84-1, Irrigation With Reclaimed Water, A Guidance Manual, p. 12-8.

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