

**Proposed California Regulations  
for Groundwater Recharge  
with Reclaimed Municipal Wastewater**

Robert H. Hultquist<sup>1</sup>, Richard H. Sakaji<sup>2</sup>,  
and Takashi Asano<sup>3</sup>, Member, ASCE

**Abstract**

The proposed California regulations for groundwater recharge with reclaimed municipal wastewater are presented with the basis and rationale for key requirements. The treatment and recharge basin requirements have been developed to control the migration of pathogens, nitrogen, and organics in the extracted groundwater. These regulations provide uniform statewide criteria that will promote groundwater recharge projects using reclaimed municipal wastewater.

**Introduction**

Despite the vast potential for groundwater recharge in California, there are few planned recharge projects using reclaimed municipal wastewater. This is partly due to economics, a situation that is rapidly changing because of the statewide need to develop additional water supplies, and the continuing concerns by local and state regulatory agencies about pathogens, nitrate, and trace organic compounds in the reclaimed water. Existing regulations require the case by case evaluation of projects and lack specific criteria and guidelines to assist in the planning of recharge projects. The lack of specific criteria and guidelines suggested that it was essential to undertake a review of the existing regulations to determine if, in the light of recent scientific studies, establishing statewide policy and guidelines for the planning and implementing new groundwater recharge projects using reclaimed municipal wastewater was warranted (Crook, *et al.*, 1990).

---

<sup>1</sup>District Engineer, Office of Drinking Water, Department of Health Services, 2151 Berkeley Way, Berkeley, CA 94704.

<sup>2</sup>Senior Sanitary Engineer, Office of Drinking Water, Department of Health Services, 2151 Berkeley Way, Berkeley, CA 94704.

<sup>3</sup>Water Reclamation Specialist, State Water Resources Control Board, P.O. Box 944212, Sacramento, CA 94244-2120; and Adjunct Professor, Department of Civil Engineering, University of California, Davis, CA 95616.

The Department of Health Services' Office of Drinking Water (ODW), under the direction of the State of California Interagency Water Reclamation Coordinating Committee (IWRCC), has reviewed the scientific literature and developed draft regulations for planned groundwater recharge projects. The IWRCC consists of representatives from the State Water Resources Control Board, the Department of Health Services, and the Department of Water Resources. The ODW Groundwater Recharge Committee included representatives from several wastewater reclamation and groundwater basin management agencies.

The ODW groundwater recharge committee used as the primary basis for these proposed regulations, the Montebello Forebay groundwater recharge project at Whittier Narrows, Los Angeles County, CA. This project was the subject of a major Health Effects Study (HES) (Nellor, *et al.*, 1985). The HES was an extensive effort to evaluate the groundwater recharge operation and to provide data necessary to enable regulatory agencies to decide at what level the recharge project could be safely continued. As an aid to evaluate the HES, the State of California established the Scientific Advisory Panel (SAP) to review the report. The SAP concluded that it was "comfortable with the current Whittier Narrows...project" (State of California, 1987). Under the direction of the IWRCC the groundwater recharge regulations have since been evolving, relying heavily on the project features demonstrated at Whittier Narrows and guiding principles provided by the SAP.

#### Proposed Regulations

The primary project site, treatment, and operational requirements of the draft regulations are presented in Table 1. The requirements are specified by "project category" which identify a set of conditions that constitute an acceptable groundwater recharge project. An equivalent level of risk is inherent in each project category when all conditions are met.

#### Pathogens

The treatment and recharge basin requirements shown in Table 1 provide a reliable barrier to prevent the passage of waterborne pathogens into the groundwater basin, thereby minimizing the risk of exposure. These requirements were developed to provide an equivalent level of risk among the different project categories by balancing the treatment and recharge basin requirements. The average log removals provided by the treatment and recharge basin requirements for each project category, shown in Figure 1, illustrate this point. The overall log removals for project Categories I, II, and V through a combination of treatment and recharge basin requirements (unsaturated zone/depth to groundwater, horizontal separation from the first domestic well, and retention time underground) achieve essentially identical log removals for viruses.

**Table 1.** Proposed Requirements for Groundwater Recharge with Reclaimed Wastewater

Project Category	I	II	III	IV	V
	Surface Spreading				Direct Injection
Maximum Reclaimed Water in Extracted Well Water (%)	50	20	20	20	50
Depth to Groundwater (ft) at Initial Percolation Rates of:					
<0.2 in/min	10	10	20	50	na <sup>L</sup>
<0.3 in/min	20	20	50	100	na <sup>L</sup>
Retention Time Underground (months)	6	6	12	12	12
Horizontal Separation (ft)	500	500	1000	1000	2000
Required Treatment					
Primary	X	X	X	X	X
Secondary	X	X	X	X	X
Filtration	X	X			X
Disinfection	X	X	X		X
Organics Removal	X				X

<sup>L</sup> not applicable

Categories III and IV are the exception to this rule. Since the treatment requirements in these project categories do not provide a sufficient barrier to remove pathogens, a much greater degree of reliance is placed on the soil-aquifer system which, overall, is felt to be less reliable than the wastewater treatment processes. Therefore, the recharge basin requirements were increased to a level that would compensate for the lower degree of treatment reliability in the soil.

#### Trace Organics

The regulations intend to control the concentration of organics of municipal wastewater origin in domestic water supply wells affected by the groundwater recharge project. Unregulated organic chemicals, those with no established maximum contaminant level (MCL), and unidentified organic chemicals are of great concern. Approximately 90% by weight of the organic chemicals comprising the total organic carbon (TOC) in treated municipal wastewater are unidentified (State

of California, 1987). One of the health concerns surrounding the unidentified organics is that an unknown but small fraction of them are mutagenic.

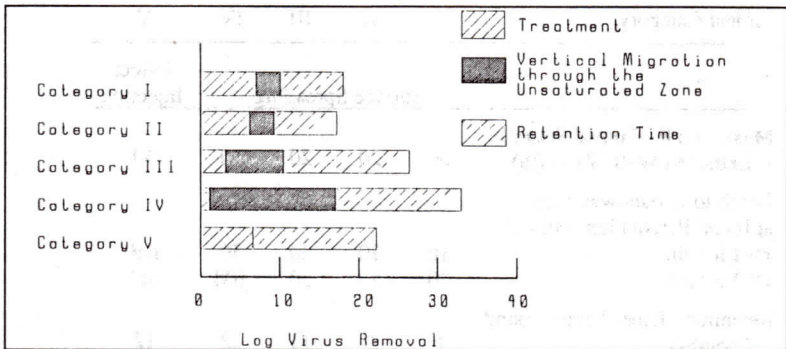


Figure 1. Virus Removal Estimates in Groundwater Recharge Systems.

TOC was chosen, as a surrogate, to represent the unregulated organics of concern. TOC is not a measure of specific compounds, but rather a measure of a class of compounds that depends on the method of oxidation (Langlois, *et al.* 1984). Due to the variability in composition, TOC is not an appropriate parameter on which to establish a health-based standard. There is insufficient basis for the establishment of a gross organics standard for the recharge water that protects public health. TOC is, however, a good collective parameter for the purpose of determining overall organics removal efficiency (McCarty, *et al.* 1982).

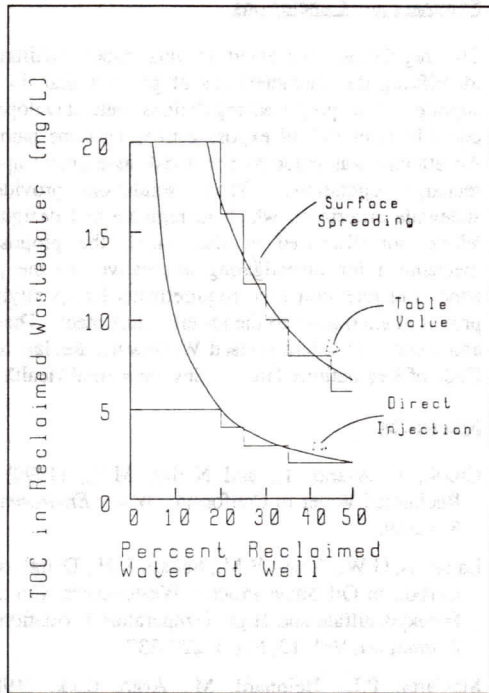
The proposed regulations shown in Table 1 require that surface spreading projects resulting in a 20-50% reclaimed wastewater contribution at any well, and direct injection projects resulting in a 0-50% contribution, must provide organics removal sufficient to limit the TOC of wastewater origin in extracted well water to 1 mg/L. The curves in Figure 2 give the maximum TOC that may be allowed in the reclaimed wastewater, for a given percent reclaimed wastewater contribution, to achieve no more than 1 mg/L TOC of wastewater origin in the well water.

The surface spreading curve assumes a 70% reduction in TOC through the unsaturated zone with no TOC removal assumed in the aquifer. The direct injection values were derived by dividing 1 mg/L TOC by the fractional contribution of reclaimed wastewater to well water. The direct injection values are 30% of the surface spreading values. Direct injection projects would have to achieve an additional 70% TOC reduction to compensate for the lack of unsaturated zone treatment.

The TOC concentrations in Table 2 are an approximation of the curves in Figure 2. The TOC concentrations are used as the treatment performance standard for the organics removal required in Table 1.

### Inorganic Chemicals

Inorganic chemicals, with the exception of nitrogen in its various forms, are adequately controlled by meeting all MCLs in the reclaimed wastewater. Nitrate must continuously be kept below its MCL throughout the groundwater basin to prevent methemoglobinemia. This means controlling the total nitrogen concentration in a groundwater recharge project.



**Figure 2.** Maximum TOC Concentrations in Reclaimed Wastewater to Achieve 1 mg/L in Extracted Well Water.

**Table 2.** Maximum Allowable Organics Concentration in Reclaimed Water Where Organics Removal is Required

Percent Reclaimed Wastewater	Maximum TOC in mg/L	
	Surface Spreading (Category I)	Direct Injection (Category V)
0-20	20	5
21-25	16	4
26-30	12	3
31-35	10	3
36-45	8	2
46-50	6	2

### Summary and Conclusions

The regulations presented in this paper facilitate the approval of projects by identifying the characteristics of projects that do not jeopardize the public water supplies. The proposed regulations were developed by attempting to establish an equal level of risk of exposure to waterborne pathogens for all project categories. An attempt was made to use a risk assessment approach to establish groundwater recharge regulations. These regulations provide, for the first time, uniform statewide criteria on which to regulate and design groundwater recharge projects. While not discussed in this paper, the proposed regulations will provide a mechanism for investigating alternatives to the proposed treatment, unsaturated zone, and retention time requirements by specifying the treatment goals that any proposed alternative to the criteria must meet. These regulations will be formalized and incorporated into revised Wastewater Reclamation Criteria (State of California, Code of Regulations Title 22 Environmental Health).

### References

- Crook, J., Asano, T., and Nellor, M.H., (1990). "Groundwater Recharge With Reclaimed Water in California." *Water Environment and Technology*. Vol. 2, No. 8, 42-49.
- Langlois, G.W., Jones, B.M., Sakaji, R.H., Daughton, C.G., (1984). "Quantitation of Carbon in Oil Shale Process Wastewaters: Coulometry coupled with Ultraviolet Peroxydisulfate and High Temperature Oxidation," *ASTM Journal of Testing and Evaluation*, Vol. 12, No. 4, 227-237.
- McCarty, P.L., Reinhard, M., Argo, D.G., (1982). "Advanced Treatment for Wastewater Reclamation at Water Factory 21," Department of Civil Engineering, Stanford University, Palo Alto, CA.
- Nellor, M.H., Baird, R.B., Smyth, J.R., (1985), "Health Aspects of Groundwater Recharge," in *Artificial Recharge of Groundwater*, T. Asano (Ed.) Butterworth Publishers, Boston, MA, 329-356
- State of California (1987), "Report of the Scientific Advisory Panel on Groundwater Recharge with Reclaimed Wastewater," State of California, State Water Resources Control Board, Department of Water Resources, and Department of Health Services, Sacramento, CA.