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Via Email
commentletters@waterboards.ca.gov

May 27, 2014

Jeanine Townsend, Clerk to the Board
State Water Resources Control Board
1001 I Street, 24th Floor
Sacramento, CA 95814

Re: Comment Letter—General Order WDRs for Recycled Water

Dear Chair Marcus and Members of the Board:

The California Farm Bureau Federation (Farm Bureau) is a non-governmental, non-profit, voluntary membership California corporation whose purpose is to protect and promote agricultural interests throughout the state of California and to find solutions to the problems of the farm, the farm home, and the rural community. Farm Bureau is California's largest farm organization, comprised of 53 county Farm Bureaus currently representing nearly 78,000 agricultural, associate, and collegiate members in 56 counties. Farm Bureau strives to protect and improve the ability of farmers and ranchers engaged in production agriculture to provide a reliable supply of food and fiber through responsible stewardship of California's resources.

Farm Bureau appreciates the opportunity to comment on the proposed General Waste Discharge Requirements for Recycled Water Use ("Proposed General Order") and presents the following remarks.

Farm Bureau supports the development and use of recycled water for a supplemental supply, especially in areas where fresh supplies may be limited or in urban areas for uses such as landscape, public parks, and golf course irrigation. Water supply and water supply reliability should continue to be a high priority in the state, especially in times of drought and heightened competition for limited water supplies. The voluntary use of water resulting from the treatment of municipal wastewater will provide a much needed additional source of water for various needs, including irrigating parks, greenbelts, playgrounds, school yards, athletic fields, golf course, cemeteries, residential and commercial landscaping, irrigation, pasture animals, and groundwater recharge, and thus potentially relieve pressures on other sources of water. Nevertheless, recycled water must be adequately treated to ensure water quality appropriate for current and future uses. The State Water Resources Control Board ("State Board") must

ensure that groundwater, as well as surface water, is not degraded by constituents in recycled water, even after effective source control, treatment, and use controls are employed.

Although Farm Bureau appreciates the State Board's willingness to streamline the process for permitting recycled water, as it has many important uses, Farm Bureau is concerned with components and limitations within the Proposed General Order that may inadvertently have negative impacts on the farming and ranching community. Farm Bureau requests the State Board to consider providing additional flexibility by revising the Proposed General Order to encompass the concerns identified below to ensure that the Proposed General Order be as workable and useful as possible.

Uses of Recycled Water

Finding 25 specifically states that "[b]y restricting the use of recycled water to title 22 requirements, this order ensures that recycled water is used safely." (Proposed General Order, p. 9, ¶25.) However, the Proposed General Order does not merely restrict the use of recycled water to Title 22 requirements; rather, it is much more restrictive and excludes allowed uses such as livestock watering and groundwater recharge.

The California Department of Public Health established comprehensive statewide regulations regarding the use of recycled water. (See Code of Regs., tit. 22, division 4, chap. 3.) These regulations specify in what manner recycled water may be used. One such allowed use is the use of recycled water for pasture animals. (See Code of Regs., tit. 22, § 60304(c)(5).) As currently drafted, the Proposed General Order would prevent the use of recycled water for animal water supply. (Proposed General Order, Prohibition 9, p. 15.) The use of recycled water for pasture animals has undergone academic analysis that supports this use. Of particular relevance is an analysis released in February 2014 by an expert panel that was convened by Dr. Dwight Bowman (Cornell University) to study the risks and benefits of using tertiary sewage water for livestock. The academic experts concluded "Title 22 standards are stringent, however, and the need for a safe source of drinking water is urgent. We believe that in this emergency situation, the overall benefits of feeding tertiary drinking water to livestock in California outweigh the risks." (Risks and Benefits of Tertiary Sewage Effluent as Drinking Water for Livestock in California, Feb. 25, 2014, p. 13, attached hereto as Attachment 1.)

Further, there is currently a bill within the Legislature, AB 2071 introduced by Assembly Member Levine, that would authorize the Department of Public Health ("DPH") to approve the use of disinfected tertiary treated recycled water for watering pasture animals if DPH determines that its use would not harm public or animal health. AB 2071 is currently moving through the legislative process and if signed into law, would establish uniform statewide recycling criteria after a stringent evaluation process. (AB 2071, "In evaluating the use of disinfected tertiary treated recycled water for the purpose of providing water to pasture animals, the State Department of Public Health shall consider all of the following: (1) Recommendations from the Advisory Panel on Constituents of Emerging Concerns in Recycled Water. (2) State-funded research performed pursuant to Section 79144 and subdivision (b) of Section 79145. (3) Research by the state board relating to unregulated pollutants.") Adopting the Proposed General

Order specifically precluding the use of recycled water for animal water supply prior to the conclusion of the legislative process would be premature.

Additional allowed uses under Title 22's stringent decontamination standards include water impoundments (Code of Regs., tit. 22, § 60305) and groundwater recharge (*Id*. at § 60320). As currently drafted, the Proposed General Order does not authorize these uses. Unfortunately, neither the General Order nor its findings state the reason for the prohibitions against groundwater recharge, groundwater replenishment activities, or the disposal of treated wastewater through percolation ponds. (See Proposed General Order, Prohibition 11, p. 15 for prohibitions.) Such uses of recycled water can put water to beneficial uses that is protective of water quality.[1]

Limitations on Amount of Use

The Proposed General Order restricts the amount of recycled water that may be applied when irrigating crops. Specifically, the Proposed General Order requires that no recycled water shall "be allowed to escape from the use area(s) as surface flow that would either pond and/or enter surface waters" (Proposed General Order, Prohibition 3, p. 14), "be applied to irrigation areas during periods when soils are saturated" (Proposed General Order, Prohibition 2, p. 14), and shall not "replenish groundwater resources" (Proposed General Order, Prohibition 11(a), p. 15). Further, the Proposed General Order limits the application of irrigation water to "agronomic rates" and requires consideration of soil, climate, and nutrient demands. (Proposed General Order, Specifications, p. 16, ¶2.) Such limitations may create targets that would be difficult and/or expensive to achieve. Further, it is not appropriate for the Proposed Order to include limiting irrigation water application to agronomic rates before recommendations by the Expert Panel have been released (see comments on the Expert Panel *infra*.)

Constituents of Concern

The Proposed General Order's Antidegradation Analysis Findings for Nitrogen state: "This General Order limits the application of nitrogen to agronomic rates." (Proposed General Order, p. 10, ¶26(b).) This statement is inconsistent with the rest of the Proposed General Order which limits the application of *recycled water*, as opposed to *nitrogen*, to agronomic rates. Given that this is a General Order of Waste Discharge Requirements for Recycled Water and not nutrients

[1] Title 22 contains specific provisions regarding the use of recycled water for groundwater recharge in order to be protective of public health:

> (a) Reclaimed water used for groundwater recharge of domestic water supply aquifers by surface spreading shall be at all times of a quality that fully protects public health. The State Department of Health Services' recommendations to the Regional Water Quality Control Boards for proposed groundwater recharge projects and for expansion of existing projects will be made on an individual case basis where the use of reclaimed water involves a potential risk to public health.
>
> (b) The State Department of Health Services' recommendations will be based on all relevant aspects of each project, including the following factors: treatment provided; effluent quality and quantity; spreading area operations; soil characteristics; hydrogeology; residence time; and distance to withdrawal.
>
> (c) The State Department of Health Services will hold a public hearing prior to making the final determination regarding the public health aspects of each groundwater recharge project. Final recommendations will be submitted to the Regional Water Quality Control Board in an expeditious manner.

(Cal. Code Regs., tit. 22, § 60320.)

or nitrogen components, Farm Bureau respectfully requests that the these findings be revised to strike the reference to the application of nitrogen. Further, it is not appropriate for the Proposed General Order to include limitations on nitrogen application especially before recommendations by the Expert Panel have been released (see comments on the Expert Panel *infra*.)

State Board's Agricultural Expert Panel

Many of the components within the Proposed General Order, such as the limitations to agronomic rates, are premature regulations due to current processes focusing on solutions in nitrate high-risk areas. Due to the significant overlap between the issues, Farm Bureau believes it important for the State Board to consider all related efforts prior to approving the Proposed General Order.

With respect to groundwater and nitrates, the State Board's February 20, 2013 Report to the Legislature made 15 recommendations to address nitrate in groundwater and many of those recommendations are underway. Recommendation 11 of the Report called for the California Department of Food and Agriculture, in coordination with the Water Boards, to convene a Nitrogen Tracking and Reporting System Task Force to identify intended outcomes and expected benefits of a nitrogen mass balance tracking system in nitrate high-risk areas. Key action areas identified by the Task Force highlight a nitrogen tracking and reporting system to provide meaningful and high quality data to help better protect groundwater quality.

Additionally, recommendation 14 in the State Board's Report to the Legislature stated, "The Water Boards will convene a panel of experts to assess existing agricultural nitrate control programs and develop recommendations, as needed, to ensure that ongoing efforts are protective of groundwater quality." The Expert Panel was convened in early May and has had four public meetings. The Expert Panel has been tasked with evaluating ongoing agricultural control measures that address nitrate in groundwater and surface water, including the use of nutrient management plans, monitoring and reporting, nutrient mass balance, assimilative capacity, and agronomic rates, all of which are components included in the Proposed General Order. On July 18, 2014, the Expert Panel will release its findings and recommendations, including new agricultural control measures, if necessary. In light of the important task undertaken by the Expert Panel, it is premature to adopt a general order that includes the above requirements prior to the conclusion of the Expert Panel process and the release of its recommendations.

Maintaining Water Quality for Those Using Recycled Water

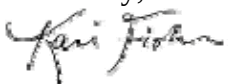
Among other water quality concerns, a major constituent of concern for Farm Bureau is salinity levels in recycled water. Excess salinity impedes crop growth and development, reduces crop yields, and can deteriorate the soil structure. Given that salinity accumulates in groundwater, there must be sufficient processes in place to insure high water quality, especially for future agricultural uses of those groundwater basins, while not burdening the grower with intensive reporting requirements and monitoring programs.

Relying upon sound science, Farm Bureau urges the State Board to continue to research the treatment of recycled water and effective source control and use control measures.

Conclusion

Thank you for the opportunity to provide our comments and concerns. Although Farm Bureau supports the use of recycled water for a supplemental supply, the use must not impair existing water rights. Further, recycled water use must be cost effective, maintain health and safety, and sustain soil productivity on a long-term basis. As currently drafted, the Proposed General Order contains various components and limitations that may negatively impact the farming and ranching community and result in unintended consequences, and it is premature to adopt the Proposed General Order at this time. We look forward to further involvement and discussion with the State Board on the use of recycled water.

Sincerely,



Kari E. Fisher
Associate Counsel

KEF/pkh

ATTACHMENT 1

Risks and Benefits of Tertiary Sewage Effluent as Drinking Water for Livestock in California

Opinions of an Expert Panel

February 25, 2014

Risks and Benefits of Tertiary Sewage Effluent as Drinking Water for Livestock in California

Opinions of an Expert Panel

Introduction

As a result of the ongoing drought emergency in California, water availability for all purposes is decreasing. In some cases, water supplies may be entirely exhausted in a matter of months. Regular sources of drinking water for livestock are rapidly approaching critical levels, creating a significant potential for dual economic and animal welfare crises.

To confront these inevitabilities, authorities and experts are considering whether other types of water sources, such as recycled wastewater, can be made available in the near term for watering livestock. One option under discussion is diverting tertiary sewage treatment plant effluent for this purpose. Tertiary sewage effluent is a filtered and disinfected wastewater that meets certain criteria as defined by the state. While such effluent has a variety of uses, it is not currently used for watering livestock. It is not explicitly prohibited, however, and the state does have the authority to allow it.

Unfortunately, little has been published on the balance of risks and benefits of such a practice. As regulators and legislators consider their options, any decisions on the matter must be made quickly and must be as well-informed as possible. Seeking advice on whether diverting such water for livestock would be an advisable option from an animal and human health standpoint, the WateReuse Association contacted Dr. Dwight Bowman of Cornell University, an expert in pathogens in manure and wastewater. In response, Dr. Bowman assembled the authors of this paper as a wider group of subject matter experts who could identify the key issues and provide insights into the level of risk this practice might involve. We achieved this dialogue through a series of short, online group meetings throughout February 2014.

Our charge was to develop a position paper on safety with regard to animal and human health. We knew that this water was already legally in use for various purposes, such as for irrigating crops destined for human consumption, including raw fruits and vegetables. We also knew that other states (Arizona)[1] and countries (Australia)[2] engage in this practice. Yet we also knew that some kinds of contaminants could be present and would raise concern; the question was one of amount and risk. We were sensitive to the fact that public acceptance would be critical, and much of our discussion occurred in this context. This document sums our collective views

[1] Ariz. Code tit 18, chap. 11, art. 3.

[2] State Government of Victoria Australia Department of Environment and Primary Industries (DEPI). *Reclaimed Water Use in Livestock Production*. February 2003, updated May 2009.

of the risks and non-risks associated with this practice, in light of its obvious benefit for dealing with a very serious problem.

Considerations

An alternate source of drinking water would be a great aid to farmers facing severe water shortage. The questions in our mind were whether it would it be safe and whether the farmers would use it. First we needed to define what we meant by "tertiary sewage effluent." We then considered whether it would be possible or practical to transport this water to the locations that needed it and, therefore, whether farmers could or would take advantage of it. Finally, the paramount consideration was whether this practice would provide a safe enough drinking source for livestock so as to be of low enough risk to animal and human health.

Our specific charge

We addressed the animal and human health implications of tertiary sewage effluent as drinking water for livestock. We did not consider state legal or regulatory parameters, with the exception of the section of California code that governs tertiary sewage effluent.

Definitions

For the purpose of this document, "tertiary sewage effluent" is that treated water defined by Title 22, §60301.230 of the California code, which sets a fairly stringent standard for contaminant removal:[3]

> **§60301.230. Disinfected tertiary recycled water.**
> "Disinfected tertiary recycled water" means a filtered and subsequently disinfected wastewater that meets the following criteria:
>
> (a) The filtered wastewater has been disinfected by either:
>
> (1) A chlorine disinfection process following filtration that provides a CT (the product of total chlorine residual and modal contact time measured at the same point) value of not less than 450 milligram-minutes per liter at all times with a modal contact time of at least 90 minutes, based on peak dry weather design flow; or
>
> (2) A disinfection process that, when combined with the filtration process, has been demonstrated to inactivate and/or remove 99.999 percent of the plaque forming units of F-specific bacteriophage MS2, or polio virus in the wastewater. A virus that is at least as resistant to disinfection as polio virus may be used for purposes of the demonstration.
>
> (b) The median concentration of total coliform bacteria measured in the disinfected effluent does not exceed an MPN of 2.2 per 100 milliliters utilizing the bacteriological

We assumed that the water that would be used would be Title 22 wastewater; if any other wastewaters (e.g., industrial wastewater) later mingle with that water, the conclusions might change.

[3] Calif. Code tit. 22, §60301.230

Cost and practicality

Having defined the kind of water under discussion, we next asked whether it would be practical to transport such water to livestock farms in California. Farmers do not currently truck or pipe in recycled water for their livestock, and we considered whether they would be interested in using the water if offered it. We believe that given the urgency of the problem, farmers will be seeking a reliable and safe water source for their animals; this option may represent the only option in some parts of the state, and near-term concerns over cost would be secondary if this water were deemed safe. Furthermore, some dairy operations already have recycled water supply lines, reducing costs for these farms. Finally, we were aware that other disaster response entities under the purview of the governor might provide reverse osmosis and other portable water treatment units to increase capacity to process the effluent for the purpose of trucking it to the livestock.

Animals

Livestock assessed were cattle, swine, and poultry.

Contaminants

Categories of contaminants considered were infectious organisms, hormones, antibiotics, chemicals, pesticides, heavy metals, and disinfection byproducts. Where appropriate, these were further subdivided into specific elements of concern.

Organics

Organic agriculture operates under different regulations than conventional agriculture. Federal and state regulations establish standards for those animals and animal products are considered organic. We did not consider the differences for the purposes of determining health impacts. We do suggest that if existing regulations allow for Title 22 usage on organic crops, then it most likely could be similarly allowable in organic livestock.

Guiding questions

As participants worked through whether tertiary sewage effluent could safely be used as drinking water for livestock, the three working questions were:

1. Does the use of tertiary-treated recycled water as a livestock drinking water source represent an elevated or unacceptable animal or human health risk relative to other available livestock watering sources?
2. If so, what measures should be taken to reduce risk to an acceptable level?
3. If insufficient information is available to make these determinations, what information is needed?

Reverse zoonoses and contaminants

Title 22 water decontamination standards are quite stringent compared to federal standards, and water that meets Title 22 standards is of high quality. Because treatment processes can vary from one plant to another, however, we needed to understand what levels of pathogens and contaminants were likely to be in an average sampling of Title 22 water.

The primary concern of the group was that tertiary effluent might provide a source of human pathogens or other contaminants for the animals consuming the water. We therefore sought to define what we knew about these pathogens and contaminants and the risks they might pose, first to the animals, and then indirectly to the public via consumption or other means.

We did not perform a quantitative risk assessment. The analysis described herein was an informal, qualitative and conceptual assessment of the relative level of risk we perceived to animal and human health from the potential contaminants we considered. It was based on the collective knowledge and experience of the members of the group. Where there was disagreement, we attempted to explain this.

We assessed the risk to be minimal in almost all cases. We did not think that the risks were high enough to preclude the use of the water for drinking by livestock during an emergency drought situation. Table 1 provides a summation of our assessments for each category and sub-category; these were intended only to inform the cost/benefit conversation in the context of other important considerations, and should be considered in this manner. Where quantitative values of contaminants present in Title 22 water were available, these are indicated the last column.

Our questions about these agents were—

1. What are the direct effects on animal health?
2. What residuals might there be in meat, milk, and eggs?
3. For the infectious organisms, to what extent might there be repopulation of animal gastrointestinal tracts with dangerous strains or resistant bacterial flora?

TABLE 1 Contaminant Levels in Title 22 Effluent and Risk from This Effluent as Drinking Water for Livestock				
Category	**Agent**	**Direct Risk**	**Risk of Amplification**	**Presence in Title 22 Effluents**
Viruses	Rotavirus	Minimal	Minimal	Present
	Reovirus	Minimal	Minimal	Present
	Hepatitis E (pigs)	Minimal	Minor	Present at very low levels
	Hepatitis E (birds)	Some	Minimal	Present at very low levels
Bacteria	*E. coli* 0157:H7	Concern	MInimal	Present (<2 CFU/10 ml)*
	Leptospira	Concern	Minimal	Present
	Salmonella	Minimal	Minimal	Present (<2.2 CFU/100ml)*
	Helicobacter	Minimal	Minimal	Present at low levels
	Campylobacter	Minimal	Minimal	Present at low levels
	Mycobacterium	Concern	Minimal	Present very low levels
	Brucella	Concern	Minimal	Present very low levels
Protozoa	*Blastocystis*	Unknown	Unknown	Present
	Giardia	Minimal	Minimal	Present (<0.1/L)*
	Cryptosporidium	Minimal	Minimal	Present (<2/L)*
	Neospora	Concern	No risk	Present low levels
	Toxoplasma	Concern	Minimal	Present low levels
Helminths	*Taenia*	Minimal	Minimal	Present *very* low levels (<1/L)
Prions	BSE, CWD**	None to minimal	None to minimal	None (BSE & CWD not in U.S)
Hormones	Estrogens	Variable depending on population; likely requires long-term use	None	Levels below minimal effect in most cases (see Appendix)
Antibiotics	Used in livestock	None	Residuals?	Low
	Human only	None	Residuals?	Low (µg/L)
Chemicals	Heavy metals	Minimal	Minimal	Present low levels
	Pesticides, etc.	Minimal	Unknown	Present low levels
	Disinfection byproducts	Minimal	Unknown	Present low levels

* Sheikh, Bahman, Cooper, Robert C.., and Danielson, Richard. "Recycled Water Food Safety Study." *Monterey County Recycling Projects* (1998):1-14; Nelson, Kara, Sheikh, Bahman, Cooper, Robert C., et al. *Efficacy of pathogen removal during full-scale operation of water reuse facilities in Monterey, California*. IWA 4th International Symposium on Wastewater Reclamation and Reuse, November 12-14, 2003, Mexico City, Mexico. Unpublished conference paper.

** BSE: bovine spongiform encephalopathy; CWD: chronic wasting disease

Infectious organisms

The presence and levels of enteric pathogens present in this recycled water were foremost in our minds. One of our most serious considerations was the potential for reverse zoonosis (zooanthroponosis). These animals could or would be receiving effluents containing human bacteria, viruses, protozoa, and helminths; prions were also a theoretical possibility. We wanted to determine as a group whether we thought that the presence and/or level of pathogens in the water would endanger the animals' health, elevate the risk of foodborne illness, or increase opportunities for antimicrobial resistant bacteria to be present in food animals. As a result, we frequently circled back to the level of treatment this water receives. As mentioned, California Title 22 sets high thresholds for disinfection, and the state has published minimum standards for chlorination, ultraviolet light treatment, ozone treatment, and pasteurization.[4] With these standards in mind, we discussed the particular pathogens of concern, and quickly ascertained their risk on a scale from none to high, given what is known about the effects that tertiary treatments can have on their viability.

Viruses

We evaluated which viruses present in human effluent might cause disease in livestock based on current knowledge and whether these viruses could resurface again in livestock feces. Some in the group expressed concern relative to a few of the viruses shed by people and their potential ability to infect and amplify in livestock. There was also some uncertainty expressed that these agents would necessarily be rendered noninfectious by the treatment used in the production of Title 22-compliant effluent. Ultimately, however, we deemed the risk from viruses to be extremely low, especially when compared to that for protozoa. The viruses that predominated our discussions were rotavirus, reovirus, and hepatitis virus.

Rotavirus. There is a potential for human strains or species of rotavirus to infect cattle. This is a fairly new field of study, however, so the lack of sufficient information led to some questioning over the level of risk. Rotaviruses are ubiquitous in bovine populations and risk of clinical disease would be restricted to calves one to two weeks of age. For poultry, the risk of infection would be virtually non-existent. Overall, the general consensus was that human rotaviruses were likely a minimal risk to animal populations in the absence of further research demonstrating otherwise.

Reovirus. Reovirus, especially type 3, is ubiquitous, but the literature suggests that it does not pose much of a hazard to livestock.

Hepatitis E. It is possible that the chlorination levels supplied by Title 22 will not inactivate the hepatitis viruses, based on older work with the human virus hepatitis A. More extensive work with "enteroviruses" has demonstrated that there are differences in inactivation rates by free

[4] U.S. Environmental Protection Agency (EPA). *2012 Guidelines for water reuse*. September 2012. (EPA/600/R-12/618).

chlorine even among closely related viruses. The concern with respect to this group of viruses is mainly relative to hepatitis E virus (HEV), which can be shared by pigs and people. Although the infection is rare in people in the United States, it has been found in effluents here, and it is possible that if HEV is in the effluent, it could be amplified in pigs receiving that effluent as drinking water. The infection does not cause significant disease in pigs, but effluent from such pig farms might contain increased hepatitis E virions. In terms of cattle, although it is conceivable that they could be infected by HEV, very little is known about their susceptibility and we believe that the risk to cattle is minimal based on a lack of reporting of the virus in cattle when adequate detection technologies are used. Chickens and other birds are now known to have their own HEV and are susceptible to disease. Thus, the concern was that environmental contamination at treatment plants by wild birds infected with avian HEV could be passed to poultry production facilities using treated water. Most plants in California, however, have covered sedimentation basins that preclude their being used as resting places by migratory waterfowl, thus minimizing the risk of fecal contamination by wild birds. The mammalian HEVs are of no risk for poultry.

Bacteria

The disinfection processes that characterize tertiary treatment are specifically designed to reduce the levels of bacteria present. We therefore assessed that levels of bacteria in tertiary-treated water would be quite low. Disinfection is relatively effective against bacteria, although some bacteria will certainly escape disinfection; as a result, some bacteria will be present in the effluent, unless the treatment plant is using a process that excludes all bacteria organisms (such as microfiltration).

The question is whether the low levels of bacteria that remain pose a heretofore-unassessed risk of reverse zoonosis if they are fed to livestock through drinking water. Will there be no effect at all, or will the practice facilitate bacterial invasion that could in turn establish reservoirs for further human infection or for antibiotic resistance? Our discussions considered a variety of bacteria, including but not limited to *E. coli* (pathogenic subtypes), *Leptospira*, *Salmonella* (non-Typhi), *Helicobacter*, *Campylobacter*, *Mycobacterium*, and *Brucella*. In most cases we spoke of them collectively. In general, we did not assess much increase in risk for human bacteria entering animal drinking water and then circling back to humans, above and beyond risks presently associated with zoonosis from livestock animals to humans. We did, however, question the impacts on animal health. It is possible that human bacteria fed to livestock could multiply. We do not have sufficient information to know the likelihood of these bacteria causing infection in the animals. We simply know that the possibility exists that livestock might become populated with them through effluent exposure.

The group generally agreed that the presence of antibiotic-resistant bacteria was a greater issue than the presence of bacteria on the whole. The risks of infection of livestock animals with antibiotic-resistant bacteria would primarily manifest in (1) potentially limiting the effectiveness of antibiotics for the treatment of sick animals, and (2) potential introduction of

antibiotic-resistant bacteria into livestock reservoirs for antibiotics that have been restricted from agricultural use to prevent this particular outcome.

Disinfection will kill most of the bacteria; however, some bacteria will survive the disinfection process. Although greatly reduced, our experience and that reported in scientific literature indicates that antibiotic-resistant bacteria may be more enriched in disinfected effluents than their non-resistant counterparts. Even in low numbers, antibiotic-resistant bacteria can establish within biofilms in trough water and share genetic resistance traits with other bacteria, including pathogens.

Complicating the assessment, we were unaware of any scientific study of the impacts of feeding antibiotic-resistant bacteria to livestock. The question of whether human bacteria entering the animal gastrointestinal system can create reservoirs and other opportunities for antibiotic resistance development is complicated. Whether and how it can promote resistance on the farm is unknown. Even at low levels of bacteria, the transfer of resistance traits could still occur. We do not believe that the low concentrations of antibiotics present in the effluent would be sufficient to promote emergence of new antibiotic-resistant bacteria (we discuss this further in the "Antibiotics" section of this paper); it is the antibiotic-resistant bacteria already in the wastewater previously shed by humans that would be of concern.

We do not believe that the risk from any of the questions posed above has been assessed well enough to enable them to be quantified. We do not believe that the risks (relative or absolute) posed by bacteria are sufficiently high to preclude the use of this water for this emergency. Greater uncertainty revolves around the risks associated with development of reservoirs of bacteria in livestock animals resistant to drugs reserved exclusively for human-use.

Protozoa

Protozoans will be partially removed by Title 22 treatment. It is likely, however, that resistant stages of some protozoan parasites will be present in the effluent. We considered the following protozoa in depth:

Blastocystis. Little is known about this protozoan organism, which encompasses about 14 subtypes of which we are currently aware. Several subtypes (ST) appear to be zoonotic and could be transmitted back from humans to animals. *Blastocystis* subtypes ST 1-10 have been found in humans; ST 1, 3, 5, 10 and 14 have been found in cattle; ST 1, 3, and 5 have been found in swine; and ST 1, 2, 6, 7, and 8 have been found in galliform birds. *Blastocystis* would likely be present in human sewage treatment plant effluent, and we have insufficient knowledge of its biology to determine what the risk from it might be.

Giardia. Overall, the risk of *Giardia* causing disease in livestock or being significantly amplified is considered minimal. The effluent will mainly contain the human species of *Giardia* or associated genetic type, although it may also include canine, feline, murine, cervid, and other forms as well. It will remain infectious within the effluent. There have been reports of the human types in cattle, but these are rare. The concern would be that the human types might

take up residence in the cattle and be amplified, enabling the cattle to serve as a new source of human infectious *Giardia*. Even this possibility, however, would be controlled by the fact that drinking water systems in California are required to protect against *Giardia* infection.

Cryptosporidium. Overall, the risk of these agents causing disease in the cattle or chickens receiving effluent as drinking water is real, but the effects should be minimal. The *Cryptosporidium* in the water will mainly be *C. hominis*, which infects only humans; it will also on occasion be contaminated with *C. parvum*, *C. canis*, *C. felis*, *C. muris*, and various other species from urban wildlife. The *C. parvum* would be capable of infecting and causing disease in calves, but most calves are infected with this agent during the first few weeks of life anyway, and older cattle tend to be refractory to disease from this species. And again, as with *Giardia*, the drinking water systems in California are required to protect against *Cryptosporidium* infection.

Neospora. *Neospora caninum* can be present in water contaminated with runoff or in sewer catchments contaminated with dog feces. Cattle can be infected with this agent, and clinical disease can have significant outcomes, notably, spontaneous abortion. The Title 22 treatment should remove the majority of the infectious oocysts of this species by filtration. California has only minimal numbers of combined sewers (storm and wastewater) entering wastewater treatment plants, so this should also minimize the impact.

Toxoplasma. *Toxoplasma gondii* would be present as the result of cat feces entering the sewage system via the direct placing of cat litter into toilets or via catchments and combined sewer production. Cattle tend to be refractory to *T. gondii* infection and disease, but it is possible that the oocysts would infect and multiply in chickens. The organisms would not be passed from chicken to chicken, and most would not have any clinical signs of infection. Thorough cooking of chicken before consumption would kill the *T. gondii* in the tissues if present. Most free-range chickens have *T. gondii* within their tissues, and again, the risk to people is minimized by the fact that chicken is usually eaten fully cooked.

Helminths

We assessed the risk from helminths to be very small. Helminths are heavier than protozoa and will be removed by settling and, because of their large size (even the eggs are large, with diameters greater than 30 micrometers), also by filtration. The concern is real, because people who are infected with *Taenia saginata* (whose eggs are infective to cattle) and *Taenia solium* (whose eggs are infective to pigs) could pose a reverse zoonosis risk, and both of these pathogens would cause condemnations if identified in animals at slaughter. However, it was our assessment that the Title 22 treatment would remove virtually all of these eggs from the effluent.

Prions

The team did not assess prions as a significant risk because they are not present in the U.S. cattle population. There has been stated concern that prions may be present in effluents from slaughterhouses and meat processing plants, which could then enter sewage treatment plants, but, again, due to the fastidious monitoring of national cattle herds by the U.S. Department of Agriculture, we considered the risk minimal. It is possible that slaughterhouses processing cervids with chronic wasting disease could be a problem, but we considered this risk zero since chronic wasting disease has not been reported in cervids in California.[5]

Hormones

Knowing hormones would be present in the water, we asked whether their levels would be sufficient to interfere with reproductive performance of breeding animals or other bodily functions. We considered the presence of estrogens, progestogens, and androgens, and found that estrogens were of greatest concern. We know they are present in human sewage as natural estrogens, as well as from human birth control medications and hormone replacement therapy, and we know that estrogens can affect breeding cattle, swine, and poultry. The question was how biologically disruptive the levels in the effluent might be. We assessed that the risk of the animals suffering ill health effects from hormones in the water was low, and would require long-term use to have an impact.

Estrogenic compounds present in effluents are known to affect the reproductive systems of aquatic animals. It is possible that they could have effects on livestock species as well, although this is much less documented, particularly at the levels of hormones that would be present in this effluent. Some research suggests that low levels could lead to disruption of reproductive cycles, but some members of the panel believed that the levels of reproductive hormones would likely be too low to interfere with reproductive performance, especially in poultry and swine. We continually returned to the fact that this water is already used for crop agriculture and the public is already exposed to it in this manner.

The circulating concentrations of the most potent natural estrogen (17 ß-estradiol) are provided for female poultry, swine, and cattle in the Appendix, in addition to the concentrations of various estrogens in wastewater treatment plant effluents around the world. Data are also presented specifically for wastewater treatment plants in California. The animals most likely to be impacted by estrogens would be cattle, as their circulating concentrations are in the range of that of some effluents. While the relative potency of the estrogens differ, the most potent form (ethinylestradiol) is typically not detected, or is found at concentrations below 1ng/L. Swine and poultry appear to be at low risk for endocrine disruption from water reuse. Swine have high natural circulating levels of estrogen, and egg-laying poultry have such naturally high levels of estrogen that the minimal additional amounts they may ingest from the water would be negligible in comparison and probably not impactful. Grazing cattle are

[5] http://www.cwd-info.org/index.php/fuseaction/news.main

potentially exposed to similar or higher concentrations of estrogens than those in the water, as a result of drinking water from streams or ponds where animals have defecated and urinated. General ill health effects are not foreseen. Overall, the risk of deleterious impact on reproductive performance of breeding livestock was considered to be greatest (but modest) for dairy and beef cattle during postpartum resumption of estrous cyclicity and during early pregnancy, and probably minimal for swine and poultry.

Additionally, we discussed whether duration of exposure could correlate to impact. It is possible that the risk might initially be low at the given level of hormones, but elevate depending on how long the animals were exposed. It is possible that effects could be present but not measurable, making monitoring efforts difficult. With enough duration of exposure, some reduction in reproductive performance could manifest, but this is probably a reasonable short-term trade-off. Even if this water ended up as a water source for years, we would still expect the impacts on animal health to be minimal since most livestock are not part of the herd for that long. Some panelists proposed that one way to mitigate risk would be to segregate those animals at greatest risk, i.e., during their breeding period, when the hormones could have the most impact. The logistical challenges of this, however, could be daunting, and probably not necessary given the low levels of hormones involved. Finally, while effects on humans over long durations of exposure in this manner are unquantifiable, no concern was voiced about transfer of elevated hormones in tissues of the livestock.

Antibiotics

Human sewage treatment plant influents contain antibiotics or their breakdown products, including those explicitly restricted from use in livestock. Antibiotics can make their way through Title 22 treatment fairly well. Title 22 water is expected to have fairly wide variation in antibiotic levels depending on the methods used at a given treatment plant. Concentrations of antibiotics in wastewater are likely to be low (in the µg/L range), and can be broken down in the presence of chlorine into inactive forms. We assessed the risk from them to livestock animal health to be low and less concerning than other categories of contaminants.

We asked whether the mingling of bacteria and antibiotics or their residues in this environment provides opportunity for resistance development. We also questioned whether such resistance could spread between bacteria via mobile genetic elements within or outside of an individual animal. Some research suggests that exposure of bacteria that are *already* resistant to an antibiotic by sub-minimum inhibitory concentration (MIC) of the antibiotic elicits expression of antibiotic-resistant traits and thickening of biofilms. The intensity of this effect at the very low concentrations in Title 22 tertiary wastewater relative to the MIC concentrations of antibiotic-resistant bacteria is not clear, but is likely to be small. Further, this phenomenon occurs in bacteria that are already resistant, and is not the same as development of new resistance. Perhaps more relevant, the susceptibility breakpoints used to assess antibiotic resistance are at the µg/mL level, orders of magnitude greater than wastewater concentrations. The concentrations of antibiotics in most wastewaters are so low (i.e., lower than MIC) that bacteria would likely be unaffected by their presence.

The primary concern raised with respect to antibiotics in wastewater was whether it could concentrate in milk and elevate antibiotic residue levels in milk. Federal allowable residue levels of antibiotics in milk are in the µg/L range, very close to the concentrations expected in wastewater. Not all participants believed that the antibiotics would concentrate in milk; others felt that data were lacking to make a determination. Milk is assiduously checked for antibiotics, and any unacceptable residues will very likely be detected by existing regulatory regimes. Impacts on farmers of contaminated milk, however, are severe, both fiscally and in terms of a given farmer's reputation as a quality milk producer. We did not reach agreement whether the majority of producers would actually be willing to run the risk of mandatory discarding of contaminated milk; but to reiterate, we assessed the risk of antibiotics actually collecting in the milk to be low.

Chemicals (heavy metals, pesticides, disinfection byproducts, and other)

Consumers will be concerned about the potential risk of consuming animal tissue containing chemicals or other residues at levels that might be markedly elevated compared to animals not drinking the effluents. Many of these trace chemicals will vary significantly among communities of smaller size due to the greater impact of a single source of waste entering a sewage treatment plant. The stringency of monitoring may be less at smaller plants due to perceived lack of risk, but these same plants might be the sources that would be utilized because of proximity to livestock. This would have to be considered on a case-by-case basis.

Categories of "chemicals" for the purpose of this paper included heavy metals, pesticides, disinfection byproducts, and a few others that arose during the discussions. We assessed the overall risk from this category of contaminants to be low.

The scientific and regulatory community has been active in monitoring household chemicals and personal care products in wastewater. Pesticides and compounds like triclosan and components of sunscreen have been detected. We do not believe that products in this category are present in high enough levels to result in acute toxicity. The problems mainly have the potential to arise with long-term exposure (on the order of years).

In addition, recent decades have demonstrated a dramatic reduction in heavy metal levels from industrial sources. Elevated levels in publicly owned treatment works are extremely unusual. Thus, in the absence of an anomalous industrial outlier, we did not have concerns about heavy metals.

Disinfection byproducts would primarily be a concern for humans in terms of carcinogenicity. We suspected that levels of such compounds are probably higher in effluent than in treated drinking water (where they have been studied), but most likely do not pose a concern for livestock. We note, however, that available information to inform this assessment is minimal.

One participant noted that sulfur can induce polioencephalomalacia in cattle; the likelihood of this occurring was deemed low because Title 22 water will have less than 1000 ppm of sulfur, which is within the safe range.

The dangers to livestock from any of these contaminants are largely undocumented, and some of the agents are not even addressed in federal drinking water standards for people. We know that they are probably present, but have no real ability to assess the levels or the impacts on animal health, making accurate and meaningful assessment of this category quite difficult.

Conclusions

Based on the tertiary treatment as defined in Title 22, we expect some pathogens and contaminants to be present in tertiary sewage effluent. We have assessed the overall risk of providing livestock with this water for drinking relative to the alternative risk of the animals running out of drinking water altogether. The risk from any water will never be zero. Title 22 standards are stringent, however, and the need for a safe source of drinking water is urgent. We believe that in this emergency situation, the overall benefits of feeding tertiary drinking water to livestock in California outweigh the risks.

The findings presented herein do not necessarily represent consensus among the participants or formal recommendations on their part or on the part of the institutions for which they work. Rather, this document reflects the collective perspective of scientists and veterinarians who had valuable input into the discussion based on their expertise and experience. We have sought at a minimum to define the risks that we perceive to the animals and to the public.

Certainly, some individuals and groups will not support the use of wastewater as drinking water for livestock. The intersections of human and animal health can prove polarizing. This has been true around the use of animal manure as fertilizer and the use of antibiotics and hormonal supplements in animal agriculture. And it may be true concerning the question of reuse of effluent water from sewage treatment plants, although we hope that this document will allay concerns by separating real from perceived risks.

We also suggest that a means to mitigate the risk would be for those implementing the practice to consider monitoring as an element of the implementation plan, such as through regular examination of hormone concentrations in the effluent. This would be especially important if Title 22 water were to become a long-term solution. It will also be important to continually reassess risk over time, as the risk of some exposures – hormones, pharmaceuticals, personal care products – might be cumulative. Additional means of mitigation would be installing activated carbon filters, or implementing RO or advanced oxidation, ideally at the treatment plant level; this would, however, be expensive and labor intensive. The water utility or the farmers using the water could opt to implement such measures, and some of the treatment plants may already be using them. Ideally, we recommend ongoing collaboration between water providers and producers to ensure animal welfare and animal products that are compliant with state and federal regulations.

While ideally we would base our recommendations on a full body of sound research, the fact is that much of the information simply has not been collected, and time does not allow us to develop and implement new research agendas. Policy decisions must often be made in the

absence of complete knowledge. We hope that the California authorities and policymakers will find this input meaningful as they make decisions regarding this serious issue.

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Appendix

Relative Potency, Stability, and Environmental and Livestock Concentrations of Estrogens

	Estrone	17 ß-Estradiol	17 α-Ethinyl Estradiol	Reference
Relative Potency	~ 0.1 – 0.01	1.0	1 - 10	1,5,14
Relative Environmental Persistence	Moderate*	low	high	9
WWTP Concentrations**	0--50 ng/L Typically <10 ng/L	0-20 ng/L Typically <2ng/L	0-6ng/L Typically ≤1ng/L	2,3,4,6,8
CA WWTP (8 plants)	Max 12ng/L 4 ND	Max 4ng/L 4 ND	Not assayed	10
Serum Concentrations				
Chicken		40-200ng/mL 40-200µg/L		12,13
Swine		2-70 pg/mL 2-70 ng/L		11
Cattle		2-10 pg/mL 2-10 ng/L		7

* Estrone appears to be more persistent in the environment, as fecal concentrations are much higher (~100 times) than 17 ß-estradiol concentrations. All mammals excrete these estrogens.

** WWTP: wastewater treatment plant

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Web link for residue limits in milk as well as detection limits of charm or snap kits:
http://www.nationaldairyfarm.com/sites/default/files/2014%20Residue%20Manual_WEB.pdf