California Regional Water Quality Control Board
Central Valley Region
ACL Complaint No. R5-2005-0501

In the Matter of Hilmar Cheese Company, Inc. and Hilmar Whey Protein, Inc.

Expert Report and Prepared Direct Testimony Regarding:

Nature, Extent, Gravity, Toxicity and Susceptibility to Cleanup

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Executive Summary

This technical report has been prepared by Kennedy/Jenks Consultants (Kennedy/Jenks) on behalf of Hilmar Cheese Company in partial response to the Administrative Civil Liability Complaint No. R5-2005-0501 (ACLC). The ACLC was issued by the Executive Officer of the California Regional Water Quality Control Board, Central Valley Region (RWQCB) to Hilmar Cheese Company, Inc. and Hilmar Whey Protein, Inc. (HCC) on 26 January 2005.

This report provides responses to several factors that the RWQCB is required to consider in evaluating civil liability in accordance with the Water Quality Enforcement Policy and Section 13327 of the California Water Code. Kennedy/Jenks provides this assessment of the nature of the discharge to Primary Lands at the HCC facility, extent and gravity of impacts, toxicity, and susceptibility to cleanup and abatement. Our conclusions are summarized below, and described in greater detail in subsequent sections of this report.

Nature of the Discharge

The constituents of interest in the HCC discharge are EC and total dissolved solids (TDS). EC and TDS are not considered characteristics of hazardous waste. Nor are they considered to be toxic, or otherwise hazardous, materials.

HCC processes milk from dairy cows as a raw material to produce cheese, lactose and whey products. The process wastewater resulting from the cheese production is treated in an onsite wastewater treatment system to remove various constituents in a series of unit processes. HCC applies the process wastewater on a land area known as the “Primary Lands” and treated water is used to irrigate to agricultural lands surrounding the HCC facility known as the “Secondary Lands.” The ACLC stems from HCC’s land application of process wastewater with levels of electrical conductivity (EC) exceeding the effluent limit of 900 µmhos/cm set forth in the Waste Discharge Requirements Order No. 97-206 (WDRs) issued to HCC in 1997.

Onsite treatment of process wastewater followed by land application is widely employed in California’s Central Valley and other agricultural areas. Conceptually, HCC’s onsite wastewater management activities are not unique or even unusual. With respect to its actual facility, HCC has exceeded the significantly norm through its construction and operation of a sophisticated wastewater treatment system to provide treatment of its milk-processing wastewater prior to land application.

The proposed ACLC penalty appears to disregard HCC’s conscientious and extensive efforts to produce wastewater with effluent EC values that comply with an unusually stringent permit condition. The ACLC overstates the nature of HCC’s wastewater discharge relative to the discharges of others containing constituents that represent a much greater potential risk to human health and the environment.

Extent of Impact

Shallow groundwater beneath and in a limited area near the HCC site contains EC/TDS at levels that are elevated relative to the range of secondary MCL values. The area of elevated EC and TDS in shallow groundwater created as a result of HCC's discharge is limited in lateral and vertical extent. Groundwater with elevated EC is confined primarily to the uppermost unconfined aquifer zone and is extremely limited within the deeper semi-confined zone where the majority of supply wells are screened. The affected groundwater is largely limited to areas beneath lands belonging either to HCC or to several of the private owners of HCC. The aquifer zone underlying the Corcoran Clay has not been affected by HCC's discharge.

The actual extent of the increase in salinity in groundwater does not support the level of financial penalty proposed in the ACLC, which appears excessive relative to the limited degree of impact to groundwater.

Gravity

Since the WDRs were issued, HCC has made significant and ongoing investments in an effort to comply with the WDRs. HCC has installed sophisticated wastewater treatment equipment, with multiple unit treatment processes. HCC has performed the routine groundwater monitoring and reporting, and has been keeping the RWQCB informed of its wastewater management activities and findings. In contrast to other cases where regulatory requirements were intentionally disregarded or not understood, this is not a matter of unresponsiveness or disregard for the requirements established by the RWQCB in the WDRs.

The potential risks to human health and the environment associated with the EC values and TDS concentrations in groundwater beneath and near the HCC facility are minimal. The financial penalty proposed in the ACLC is disproportionate to the actual gravity of the circumstances associated with HCC's land application of wastewater and the resulting EC and TDS concentrations in shallow groundwater.

Toxicity

The inorganic constituents responsible for the areas of elevated EC and TDS in groundwater are not toxic and do not represent a threat to human health. In fact, some community water supply systems in the Central Valley routinely provide groundwater with naturally-occurring EC and TDS concentrations between the lower and upper secondary MCL values.

The shallow groundwater containing elevated EC and TDS concentrations is not used for domestic water supply purposes. HCC has offered to provide, and continues to provide, bottled water to nearby residents who have expressed concern regarding their water supply wells.

Kennedy/Jenks is not aware of any actual agricultural users of groundwater in the vicinity of Hilmar that have been impacted. Almonds are grown in the vicinity of the facility. However, these are grown on property owned by co-owners of HCC and irrigated using water supplied by TID. There are no salt-sensitive crops known to be irrigated with groundwater impacted by HCC's land application activities.

In that there is no unmitigated risk to human health, wildlife or to crops associated with the elevated EC and TDS in shallow groundwater beneath the HCC site, the financial penalty proposed in the ACLC is not commensurate with the degree of actual or potential environmental harm.

In contrast, the proposed ACLC penalty is much more consistent with circumstances where toxic constituents of anthropogenic origin have impacted a sole-source water supply, circumstances not present in the case of HCC.

Susceptibility to Cleanup and Abatement

Hilmar has invested substantial resources in the continued expansion and improvement of its wastewater treatment systems. The most effective form of abatement going forward is through continued operation and improvement of the HCC wastewater treatment system.

Groundwater containing EC and TDS beneath the HCC site is susceptible to cleanup and abatement. Attenuation already occurring at the site serves to limit the extent of elevated EC and TDS in groundwater and is all that may be required. HCC's ongoing measures to decrease the mass loading of salinity in the discharge through source reduction and treatment will result in further abatement. If necessary, groundwater beneath the HCC site could be remediated by active measures such as groundwater extraction and aboveground treatment to remove inorganic dissolved solids.

The penalty proposed in the ACLC appears to consider the change in salt concentrations in groundwater as being permanent and not susceptible to abatement, which is not commensurate with the actual situation. The resources contemplated by the proposed penalty could be more beneficially invested by HCC to improve the effectiveness and reliability of the existing process wastewater management system.

Section 1: Introduction

Kennedy/Jenks has been retained by Hilmar Cheese Company to prepare this response to Administrative Civil Liability Complaint No. R5-2005-0501 (ACLC). The ACLC was issued by the Executive Officer of the California Regional Water Quality Control Board, Central Valley Region (RWQCB) to Hilmar Cheese Company, Inc. and Hilmar Whey Protein, Inc. (HCC) on 26 January 2005. A subsequent staff report was issued in April 2005 by the RWQCB staff to justify the ACLC.

The ACLC pertains to management of process wastewater at HCC's cheese processing facility located at 9001 North Lander Avenue in Hilmar, California (Figure 1). The ACLC alleges that HCC violated the specifications of its Waste Discharge Requirements Order No. 97-206 (WDRs) during the period from 27 January 2002 through 30 November 2004 by exceeding the wastewater effluent discharge limit for electrical conductivity (EC) of 900 micromhos per centimeter (µmhos/cm), and that the land application of this wastewater effluent resulted in adverse impacts to groundwater quality (RWQCB 2005a).

1.1 Purpose

Kennedy/Jenks prepared this evaluation to provide a technical opinion concerning several of the factors that the RWQCB is required to consider in assessing a proposed penalty for the ACLC. The factors addressed by Kennedy/Jenks are: nature of the discharge, extent of impact(s), gravity, toxicity, and susceptibility to cleanup and abatement.

With the respect to the factors considered in this report, the staff report alleges that HCC regularly discharged wastewater to the Primary Lands with salt content not meeting the effluent limitation prescribed in the WDRs, resulting in adverse impacts to groundwater quality. The EC limit violations are stated to have caused or contributed to the pollution of groundwater from EC and TDS, and to have threatened pollution from sodium, chloride, and ammonia with potential for downward vertical migration causing water quality degradation at depth. With respect to the toxicity of the EC limit violation(s), increased salinity in groundwater may affect production of salt-sensitive crops.

The evaluation presented in this report is based on review and analysis of existing data to further characterize the subsurface conditions and develop a conceptual site hydrogeological model. This conceptual model is used to assess the extent and gravity of the impact to groundwater associated with land application of wastewater from the HCC cheese processing facility.

1.2 Sources of Information

Much of the site-specific information used in this technical evaluation was obtained from reports prepared by Brown and Caldwell on behalf of HCC. Kennedy/Jenks relied upon technical information, including information contained in several Brown and Caldwell documents, for the evaluation and in developing our opinions. The technical information from documents listed in the References section included:

- Analytical results from samples from groundwater monitoring wells installed by HCC
- Well construction and soil boring logs
- Analytical results from samples collected from water supply wells located within one-half mile of HCC site
- Land use information around the HCC site
- Water level data from HCC monitoring wells

In addition to the empirical data, Kennedy/Jenks utilized the USGS groundwater model MODFLOW/MT3D to enhance our understanding of the hydraulic and transport mechanisms of the area being characterized (see Section 4). The computer model confirms the findings of the sampling data regarding the distribution of EC and TDS in groundwater beneath the site.

1.3 Qualifications of Preparers

1.3.1 Kennedy/Jenks – The Firm

Kennedy/Jenks is a professional services corporation providing engineering and environmental science consulting services. Kennedy/Jenks has been in business for more than eight decades, and has a number of offices and many long-term employees in California. Kennedy/Jenks' client-base includes both public sector and private sector clients. In California, our consulting services are largely in areas pertaining to environmental engineering, water supply, wastewater management, groundwater characterization and remediation, and environmental compliance.

1.3.2 Kennedy/Jenks – Project Staff

1.3.2.1 Paula J. Hansen

Ms. Hansen is a Senior Engineer at Kennedy/Jenks. She has 23 years of professional experience as a chemical engineer, 14 of these in environmental consulting. Ms. Hansen obtained a Bachelor of Science in Chemical Engineering from Purdue University and a Master of Science in Chemical Engineering from the University of California, Berkeley.

Ms. Hansen has been employed with Kennedy/Jenks since 2000. She has spent a significant portion of her recent career assisting food processing clients in California with various wastewater management and land application issues.

1.3.2.2 Leslie L. Chau

Mr. Chau is a Principal Hydrogeologist and Operations Manager for the Information Solutions Group at Kennedy/Jenks. Mr. Chau completed his Bachelor of Science degree in Geophysics at the University of California, Berkeley and his Master of Science in Geology at the University of California, Riverside. He has 18 years of professional experience as a hydrogeologist, including mapping, water resources and fate and transport modeling. Mr. Chau is currently involved in several projects for food and beverage clients in California's Central Valley, where he has been leading efforts to characterize groundwater conditions. Mr. Chau has been employed by Kennedy/Jenks since 2001.

1.3.2.3 Michael Maley, C.HG., C.E.G., P.G., P.E.

Michael Maley is a Principal Hydrogeologist with 18 years of significant project experience in developing hydrogeologic interpretations in complex geologic settings and applying numerical models for water resource and environmental projects. Mr. Maley completed his Bachelor of Science degree in Geology at Texas Christian University, his Master of Science in Geology at University of Oklahoma and his Master of Science in Geological Engineering at University of Missouri – Rolla. Mr. Maley has been employed by Kennedy/Jenks since 2005.

Section 2: Nature of the Discharge

2.1 Hilmar Processing Facility

The HCC cheese processing facility and adjoining wastewater land application areas are located outside the town of Hilmar in Merced County, California (Figure 2). The HCC facility is a large single-site cheese and whey products manufacturer. The facility began production in 1985 and currently employs more than 600 people. Over 11 million pounds (over 484,000 liters) of milk are received each day from over 270 dairies and 120,000 dairy cows. The HCC facility produces over 1 million pounds (over 450 metric tons) of cheese each day for use in food service, ingredients, retail and the restaurant trade. The HCC facility also produces over 350,000 pounds (over 150 metric tons) of whey protein and lactose powder per day.

2.2 Process Wastewater Management

In the course of producing the cheese, the facility generates process wastewater, which is treated in an extensive onsite process wastewater treatment system that has undergone modification and expansion over the course of time.

Process wastewater generated at the HCC facility has been land applied in areas known as the Primary Lands (Figure 2) since 1985 (Brown and Caldwell 2004). With the increase in wastewater production, additional source reduction and treatment was added to decrease constituent loading to the Primary Lands. Commencing in 1997, treatment of the process wastewater was installed that included the VSEP® (Vibratory Shear Enhanced Processing) membrane system in conjunction with nanofiltration technologies.

Beginning in 2000, a portion of the wastewater flow was treated using reverse osmosis (RO) membrane-base separation. The RO-treated wastewater flow averaged about 0.62 MGD from 2001 to 2003. The portion of the wastewater flow that was treated through RO is stored in ponds and then used to irrigate an area of approximately 400 acres (the Secondary Lands) north and west of the existing Primary Lands application area (Figure 2). These Secondary Lands have not received partially treated or untreated wastewater.

By late 2002, HCC was treating approximately 50 to 60 percent of the wastewater produced using equalization, dissolved air flotation, sand filtration, and RO. In 2004, anaerobic biological treatment and aerobic polishing through a sequencing batch reactor (SBR) system were added. HCC has made significant investments of financial and staff resources to expand and improve its process wastewater treatment system(s). The efforts and expenditures by HCC to meet permit conditions by implementing source reduction and to install, modify, test and upgrade treatment equipment to reduce the organic and inorganic mass loading associated with the process wastewater have been on the order of 80 million dollars. According to HCC staff, its expenditures to date have exceeded those of other food processors, including other milk processing facilities.

2.3 Process Wastewater Discharge

HCC has clearly documented the volume and character of the wastewater applied to the Primary Lands. Based on HCC's self-monitoring data, HCC discharged water to the Primary Lands averaging 2,700 µmhos/cm and having a monthly average EC ranging from 1,750 to 4,160 µmhos/cm during the ACLC period. Measurements of EC reflect the dissolved inorganic constituents and in the case of HCC's discharge, ionized organic acids such as lactic acid, facilitating the conduct of electrical current through the water. The process wastewater contained inorganic constituents in varying proportion. The primary constituents in the discharge include:

bicarbonate alkalinity (approx. 25% of the inorganic fraction)

sodium (approx. 23%)

potassium (approx. 16%)

chloride (approx. 13%)

calcium (approx. 8%)

nitrate (approx. 7%)

phosphorus (approx. 6%)

These inorganic constituents are all naturally-occurring materials found in soil matrices and ambient groundwater in varying amounts. None are toxic or hazardous in nature. Alkalinity and calcium are typically major inorganic dissolved components of groundwater. Potassium and nitrate are necessary plant nutrients, which are taken up from soil by crops. Nitrogen is stored in soil and converted to the form of nitrate (available to plants) in the soil at different rates depending on temperature, chemical make-up of the soil, etc. Potassium, nitrogen and phosphorus are all included in fertilizer formulations used as soil amendments on lands in much of the Central Valley.

A primary aspect of evaluating the potential effects of inorganic salinity constituents in water is the use of the water. In the case of groundwater underlying and in the vicinity of HCC's site, the most probable potential uses are domestic and agricultural supply. The land uses in the vicinity of the HCC facility include agricultural (row crops, tree nuts), dairy operations and limited residential occupancy.

Water quality objectives for surface and groundwater are sometimes established using Primary Maximum Contaminant Levels (MCLs), which were promulgated for regulation of the quality of water that can be served by community water systems, as guidance. Primary MCLs are established for protection of human health and generally established for toxic constituents, which could threaten human health if consumed in sufficient quantities.

Secondary MCLs, as set forth in Section 64449(a) of the California Water Code, are established for constituents that may affect aesthetic considerations such as taste, odor and appearance. Secondary MCLs provide guidance for quantities "not to be exceeded in the water supplied to the public by community water supply systems," and can be waived by the Department of Health Services based on customer acceptance or economic considerations. The use of MCLs, particularly secondary MCLs, to establish limits for effluent process wastewater is severely flawed. However, the constituents in HCC's discharge can be evaluated in relation to MCLs for the purpose of considering risk levels to human health.

Of the constituents listed above, nitrate is the only compound for which a primary MCL has been established. Based on analytical results for samples collected from HCC's network of groundwater monitoring wells, nitrogen (reflected in measurements of TKN, nitrate, and ammonia) in the process wastewater discharged to the Primary Lands has not resulted in levels of nitrate above the MCL to be present in groundwater underlying or downgradient of the application areas. Concentrations of nitrate as nitrogen measured in groundwater in the uppermost aquifer zone from the area underlying and closest to the Primary Lands are low, ranging from nondectable levels of < 0.1 milligrams per liter (mg/l) to 19 mg/l. The nitrate in the process wastewater discharge is effectively denitrified in the soil column / vadose zone underlying the wastewater application areas.

No primary MCLs have been established for EC and total dissolved solids (TDS). TDS/EC and the other individual inorganic constituents in HCC's effluent wastewater are not considered to be toxic or potentially hazardous, nor are they considered to be disease-causing.

Secondary MCL ranges have been established for EC, TDS and chloride. These are:

- EC: 900 – 1,600 µmhos/cm
- TDS: 500 – 1,000 mg/l
- Chloride: 250 - 500 mg/l

The inorganic constituents in HCC's wastewater are also present in the ambient groundwater in the vicinity of the site, in varying amounts. These constituents are dissolved from the soil matrix as percolating rainwater or irrigation water moves downward through the soil vadose zone above the water table and as the groundwater migrates horizontally through the soil formation(s).

The question of agricultural sensitivity to the inorganic constituents in HCC's effluent wastewater is also relevant. According to research results published in the literature such as in Ayers and Westcott (1994), crop species have varying tolerance and sensitivity to salt, as discussed in Section 6. Some crops can produce acceptable yields at much higher salinities than others due to plant mechanisms that regulate osmotic pressure.

The ions of primary concern for salt toxicity in the root zone are chloride, sodium and boron. Chloride and sodium can also be toxic when taken up by leaves during spray irrigation. Soil type and structure influence the permeability of the root zone and rate of infiltration; slow drainage contributes to salt accrual and clogging and a shallow water table may also facilitate salt accumulation.

The potential impacts of HCC's effluent wastewater must be placed in the context of general salinity buildup in the subsurface and groundwater in many areas of the Central Valley. Salinity management is a significant issue across the state of California and is associated with many activities of modern human habitation, wastewater collection and land disposal, and particularly irrigated agriculture.

As reported by HCC to the RWQCB, the wastewater from HCC's cheese production facility contains constituents contributing to EC and TDS, including inorganic dissolved salts and organic acids. EC and TDS are not toxic constituents and do not threaten human health or wildlife in the concentrations found in HCC's wastewater. Constituents such as biological materials, undisinfected pathogens, toxic constituents, metals and solvents are not present in HCC's wastewater.

HCC manages its wastewater in a manner consistent with that performed by industries across California's Central Valley, where there is not an extensive wastewater collection system or municipal treatment capacity. The penalty proposed by the ACLC severely overstates the nature of HCC's wastewater and constitutes an undue punishment for Hilmar's ongoing efforts to improve its wastewater management systems.

Section 3: Evaluation of Subsurface Condition

3.1 Background Information

Information used in the evaluation of the subsurface conditions and the potential impact of HCC's land application practices is outlined in this section.

3.1.1 Land Use

An understanding of local land use in the area surrounding the HCC facility is important in understanding the groundwater quality of the area. Much of the area surrounding the HCC facility is owned either directly by HCC or the owners of HCC. The location of HCC and HCC-owner owned lands is shown on Figure 3.

Dairies and farm activities in the area may also impact groundwater through their operations (e.g., fertilizers) and management of waste products. Also, many of these dairy operations sell their milk products to HCC.

Within one-half mile of the HCC facility, the land use is primarily agricultural with a mixture of orchards and pasture crops (Figure 4). The dominant crops grown near the facility include alfalfa, corn, oats, peaches and almonds (Brown and Caldwell 2004). Typically, forage crops in the area are irrigated by flood or furrow systems, whereas orchard crops are irrigated by flood, furrow, or micro-irrigation systems. Typically, crops are irrigated using TID supply water. A significant portion of the area surrounding the HCC facility consists of dairy/livestock operations (Figure 4). Rural residential sites are also scattered throughout the area. The town of Hilmar lies south of the site and consists primarily of single-family residential housing, businesses, and mobile home parks.

3.1.2 Soil and Groundwater Information

Several previous groundwater investigations have been conducted by HCC to characterize the soil and groundwater conditions. The hydrogeologic evaluation and the figures and tables presented in this report are based on data obtained from these previous investigations. These data are compiled and included in the following appendices:

- A Historic Groundwater Elevations
- B Historic Analytical Results for Samples Collected from Hilmar Monitoring Wells
- C Historic Analytical Results for Samples Collected from Hilmar Water Supply Wells
- D Well Construction and Sampling Information for Domestic Wells
- E Analytical Results for Samples Collected from Domestic Wells in May 2005

3.1.3 Water Supply Wells

HCC has three water supply wells used to produce groundwater for the plant operations. Two water supply wells are located in the southeast corner of the facility property. Well IN-1 (also known as HCC Well 1) was drilled in 1989 and Well IN-2 (also known as HCC Well 2) was drilled in 1985. A third supply well, Well IN-7 (also known as HCC Well 4), located north of the facility, was drilled in 2003. The locations of these wells are shown on Figure 5. The well specifications are listed in Table 1 and Appendix D.

Water for the town of Hilmar is supplied by the Hilmar County Water District (HCWD) from three public water supply wells along Golf Links Road northeast and upgradient of the HCC facility. Water supply for the farms and dairies surrounding the site is supplied by private domestic and irrigation wells. The approximate locations of the majority of the domestic wells (DW) and irrigation wells (IW) used in this investigation are shown on Figure 5. Other wells not known to HCC may exist (Brown and Caldwell; 2004, 2005a).

3.1.4 Irrigation Practices

The agricultural lands surrounding the HCC facility are typically irrigated using water supplied by the Turlock Irrigation District (TID) or, in some instances, groundwater. Irrigation practices on the surrounding lands affect groundwater behavior and quality. TID serves over 5,800 irrigation customers located across approximately 150,000 acres of farmland. Most of the land within the TID is flood irrigated, but the TID also serves the needs of growers with drip and micro-irrigation systems. The TID irrigation season traditionally runs from 15 March to 15 October, though weather conditions often change the start and finish dates in a given year. Each year, the TID sets a water allotment for growers, based on anticipated runoff in the Tuolumne River watershed. The Tuolumne River is the source of most of the TID water. In dry years, the TID relies on conjunctive use of groundwater pumped into the canal system.

The TID owns and operates more than 250 miles of canals stretching from La Grange Dam on the Tuolumne River to the San Joaquin River. With a few small exceptions, the system is gravity-fed. More than 90 percent of the canals are concrete lined. The TID lateral network is connected to the San Joaquin River (Brown and Caldwell 2005b). TID Lateral No. 6 runs across the area and along the northern edge of the HCC Primary Lands (Figure 5).

3.1.5 Tile Drain System

Shallow groundwater and surface water are collected in certain areas by local tile drain systems installed and operated by the TID. The tile drains are a network of pipes installed to lower the shallow groundwater level so that it does not adversely affect the roots of the crops particularly during the irrigation season. Figure 5 shows the location of two of the tile drain systems located near to the HCC facility.

Located southwest of the HCC facility is the TID Nyman Drain Improvement District, D-9061 (Figure 5). The drainage lines are constructed of corrugated perforated 10-inch pipe (main lines) and 4-inch pipe (lateral lines). The depths of the drainage lines range from 14 feet below ground surface (bgs) at the lowest point at the TID pump station to 6 feet bgs at the furthest northeastern extension. The water is pumped and discharged directly to Lateral No. 6. From April 1997 through November 2004, the TID reported a total flow of 13,800 acre-feet in the Nyman Drain with an average flow of 1.6 million gallons per day (MGD) or 4.9 acre-feet per day (Brown and Caldwell 2005b).

HCC has avoided applying wastewater to land served by the tile drains to avoid the potential for wastewater to enter the tile drain system. To that end, HCC has plugged or removed some sections of drainage pipes near the Primary Lands.

3.2 Hydrogeology

3.2.1 Regional Geology

The HCC facility is located in the San Joaquin Valley in the southern part of the Central Valley of California. This physiographic province consists of low alluvial plains and fans. The broad alluvial plains slope westward away from the Sierra Nevada and toward the San Joaquin River. The geology of the upper 300 feet below the Hilmar area consists of alluvial and lacustrine deposits of Holocene to Pleistocene in age. Grain size can vary from fine-grained to coarse-grained over short distances and depth intervals (Page and Balding 1973).

The shallowest sediments in the Hilmar area are considered as part of the Modesto Formation, which consists of a heterogeneous mixture of continentally derived, poorly sorted sediments of Holocene to Pleistocene in age.

Below the Modesto Formation are older alluvial units that are considered part of the Turlock Lake Formation (which is equivalent to the Tulare Formation) of Pleistocene age. These older alluvial units consist of interbedded lacustrine and marsh deposits of fine-grained silts and clays (Page and Balding 1973). The Corcoran Clay Member of the Turlock Lake Formation extends over a large portion of the Central Valley and is comprised of lacustrine and marsh deposits of silt, silty clay, and clay and is gray to blue in color. Below the Corcoran Clay Member are additional deposits of the older alluvium. The texture and character of these deposits are similar to the older alluvium of the Turlock Lake Formation above the Corcoran Clay (Page and Balding 1973).

3.2.2 Site Specific Hydrogeology

Three geologic cross sections (Figures 6, 7 and 8) were constructed across the site as part of this hydrogeologic evaluation. The geology beneath the HCC site is dominated by a heterogeneous sequence of interbedded sands, gravels, silts and clays.

On all three cross sections, a shallow sand and gravel layer is noted from the ground surface down to a depth of 15 to 20 bgs or an elevation of approximately 75 to 70 feet relative to mean sea level (msl) as shown on Figures 6, 7 and 8. From 20 to 70 feet bgs (elevation 70 to 20 feet msl), the sequence consists of a more heterogeneous mixture of sand, gravel, silt and clays. The sand layers appear to be more discontinuous and lenticular in the interval extending from 20 to 70 feet bgs. The sequence from ground surface to 75 feet bgs (elevation 90 to 15 feet msl) is interpreted as the younger alluvium of the Modesto Formation.

Below the Modesto Formation is the older alluvium of the Turlock Lake Formation. The Turlock Lake Formation is composed of several distinct intervals as shown on Figures 6, 7 and 8. The interval from approximately 75 to 125 feet (elevation 15 to -35 feet msl) is interpreted as the upper alluvium of the Turlock Lake Formation. The Corcoran Clay Member of the Turlock Lake Formation occurs from approximately 125 to 200 feet (elevation -35 to -110 feet msl); however, the thickness of the Corcoran Clay appears to vary across the site. Below the Corcoran Clay is the lower alluvium of the Turlock Lake Formation. Few wells near the site penetrate through this lower alluvium.

The contact between these Modesto and Turlock Lake Formations is interpreted as occurring at approximately 70 to 80 feet bgs. The interval from about 60 to 80 feet bgs is more notably fine-grained and fine-grained layers are interpreted as extending across the entire site. Also, hardpan layers of highly-cemented sediments were noted during site investigations by Nolte (1995) at depths of 70 to 80 feet bgs (elevation 20 to 10 feet msl). Hardpan layers typically represent ancient soil horizons that form during periods of nondeposition. Therefore, the geologic units above and below these hardpan layers have been deposited during different periods in geologic time. With respect to groundwater, these hardpan layers inhibit vertical hydraulic flow from units above and below these layers, and can act as confining or semi-confining layers to the deeper units.

The character and texture of the older alluvium of the Turlock Lake Formation is considered similar but coarser-grained than the younger alluvium of the Modesto Formation. A distinct sand layer that appears to be largely continuous across the site occurs at depths of 80 to 110 feet bgs (elevation 10 to -20 feet msl).

The Corcoran Clay is noted by a 50 to 100 foot thick sequence of primarily blue clay. Most geologic logs for wells at the site note this blue clay as occurring from depths ranging from 110 to 210 feet bgs (elevation -20 to -120 feet msl). However, the thickness of the Corcoran Clay appears to vary across the site. Sand lenses occur within the Corcoran Clay and are noted in geologic logs across the site. The Corcoran Clay is noted to interfinger with alluvial deposits in the Central Valley as the lake where the Corcoran Clay was deposited expanded and contracted.

The lower alluvium of the Turlock Lake Formation is below the Corcoran Clay Member. In boring logs for wells that penetrate to these depths, the sediments also include heterogeneous interbeds of sands, gravels, silts and clays. A thick sand layer is noted from depths of 160 to 190 feet bgs (elevation -70 to -100 feet msl). This layer is interpreted to represent the lower alluvium below the Corcoran Clay.

3.3 Groundwater Units

The HCC facility is located within the Turlock groundwater subbasin that forms part of the San Joaquin Valley groundwater basin (DWR 2004). Within the Turlock subbasin, the younger alluvium, which forms the shallow aquifer, in most places, will yield only moderate quantities of water. The lacustrine and marsh deposits, which form the less permeable “semi-confining” zone between the shallow and deeper groundwater aquifers, generally yield only little water to wells (DWR 2004). The deeper, older alluvium represents the most extensively developed aquifer, where the majority of the water supply wells are screened.

In Bulletin 118, DWR has divided the sediments in the subbasin into three aquifer types. As applied to the area around the HCC facility, these aquifers include the:

Unconfined Aquifer: The unconfined groundwater beneath the HCC facility is interpreted as the interval equivalent to the Modesto Formation from depths ranging from ground surface to 75 feet bgs (elevation 90 to 15 feet msl). Comparison of hydrographs for well pairs MW-11/18 and MW-12/19 at the HCC site show similar groundwater levels and trends over time indicating that the sand and gravel layers within the Modesto Formation are relatively well interconnected. The depth to groundwater in the unconfined aquifer typically ranges from 1 to 15 feet bgs depending upon the season, amount of precipitation and local irrigation practices.

Semi-Confined Aquifer: The semi-confined aquifer is the interval of the Turlock Lake Formation that exists below the Modesto Formation and above the Corcoran Clay from depths ranging from 75 feet bgs to 125 feet bgs (elevation 15 to -35 feet msl). The older alluvium is considered coarser-grained than the younger alluvium in the unconfined aquifer, and therefore, is considered a more productive water-bearing zone. Most water supply wells near the HCC facility are completed in the semi-confined aquifer.

The aquifer is semi-confined due to the overlying interbeds of fine-grained sediments and hardpan layers that act as confining units and impede vertical groundwater flow between the unconfined and semi-confined aquifers (Bertoldi, et al, 1991).

Confined Aquifer: The confined aquifer includes the interval of older alluvium below the Corcoran Clay from depths ranging from approximately 200 feet bgs to 300 feet bgs (elevation -110 to -210 feet msl). Few wells within one-half mile of the HCC facility have been drilled to this depth so that only limited site-specific data are available.

The Corcoran Clay forms a regional confining layer throughout the area. This continuous clay layer provides a significant regional confining layer. In parts of the San Joaquin Valley, groundwater elevation differences of 200 feet have been reported between units above and below the confining layer. This magnitude of groundwater elevation difference signifies that little vertical hydraulic communication would be expected across the Corcoran Clay.

3.4 Groundwater Flow

Groundwater flow is highly variable near the HCC site. Groundwater elevation data is available from the HCC monitoring wells installed in the unconfined aquifer. As noted in Table 1, 18 of the 20 HCC groundwater monitoring wells are screened at depth intervals of 10 to 20 feet bgs. Two wells are screened at depth intervals of 50 to 60 feet bgs. Ten of the wells are perimeter wells and were installed outside of, or around the perimeter of, the Primary Lands application areas (Brown and Caldwell 2004). Using the data collected at these wells, a series of groundwater elevation contour maps are presented on Figure 9 for March 2002, September 2002, March 2004 and September 2004 for the unconfined aquifer. These maps show a strong seasonal variation.

The groundwater elevation maps for March 2002 and March 2004 show groundwater flow is generally from northeast to southwest across the site with a hydraulic gradient of approximately 0.001 feet/foot (Figure 9). In the winter and spring, reduced agricultural activities and greater precipitation allow for a more consistent groundwater gradient to develop across the site. Groundwater flow in the shallow, unconfined aquifer appears to be influenced by the tile drain systems especially to south of the site as indicated by data from Wells MW-14 and MW-17. The hydraulic gradient steepens to 0.002 feet/foot in the vicinity of the tile drain systems (Figure 9). No groundwater elevation data are available to the south of the tile drain system; however, shallow groundwater flow south of the drain is also expected to converge towards the tile drain system.

The groundwater elevation maps for September 2002 and September 2004 show that a more variable gradient develops with localized mounds and depressions (Figure 9) due to agricultural impacts from agricultural pumping, return flows and drainage. Groundwater depressions noted near Wells MW-13 and 15 along the eastern margin of the site are interpreted to represent groundwater pumping for agricultural usage. Wells in this area have well screens or gravel packs that extend into the unconfined aquifer. A slight groundwater mound is indicated by data from Wells MW-2, 6, 7 and 9 along the central and western portions of the site. A groundwater gradient towards the tile drain system south of the site is observed. The steeper hydraulic gradient towards the northwest as shown by Well MW-16 is interpreted to represent a combination of effects from the drainage system and agricultural pumpage in the unconfined aquifer (Figure 9). Furthermore, in the eastern and northern portions of the site, the hydraulic gradient reverses seasonally. These reversals in groundwater flow directions would have the effect of limiting the movement of groundwater underlying the HCC application areas.

3.5 Water Quality

Water quality data have been collected on a regular basis at the site since 1989 from the shallow monitoring wells installed by HCC in accordance with RWQCB requirements to allow ongoing monitoring of the shallow groundwater. Monthly groundwater sampling and reporting conducted in accordance with conditions in the WDRs is summarized in Appendix B.

In 2005, groundwater samples were collected from 68 water supply wells located within a half-mile radius of the HCC site (Brown and Caldwell 2005a). Analytical results from recent sampling of water supply wells located within one-half mile radius of the HCC facility is presented in Appendix C.

Data from both the HCC monitoring wells and the recent sampling of water supply wells were used to evaluate water quality in the vicinity of the HCC site and the distribution of characteristics and potential extent of impacts from discharge of process wastewater.

3.5.1 Aquifer Assignments

Monitoring and domestic supply wells were mapped by groundwater aquifer to facilitate the subsurface evaluation. The majority of wells were assigned to the groundwater aquifer based upon their listed well screen interval. Screened intervals were not available for several wells included in the domestic well sampling program. For these wells, the aquifer assignment was inferred upon association with nearby wells and interpretation of the water quality data. For example, water supply wells without identified screened intervals were generally assigned to the semi-confined aquifer because most wells in the area are completed within this zone.

In addition, in those areas that also included wells with known screened intervals, well assignments were further refined based upon associating those wells with similar water quality data. This method worked well for 87 out of 88 wells. An uncertain assignment is noted for Well IW-4, which has a known screened interval. The screened interval placed it within the Corcoran Clay. However, the water quality was clearly most consistent with data from nearby wells completed within the unconfined aquifer. Well IW-4 does have a gravel pack extending up to 50 feet bgs, which is within the unconfined aquifer. Based on this, Well IW-4 is included on the unconfined aquifer water quality maps.

In summary, data from the 88 monitoring and water supply wells were used in this water quality evaluation. Of these, 37 wells were assigned to the unconfined aquifer, 44 to the semi-confined aquifer, 1 to the Corcoran Clay, and 6 to the confined aquifer (Table 1). Of the 88 wells, 57 had known screened intervals, whereas 30 were assigned using the method discussed above. Of the 30 wells with inferred aquifer assignments, 13 were assigned to the unconfined aquifer and 17 were assigned to the semi-confined aquifer. Well locations are shown on Figure 5.

3.5.2 Distribution of Electrical Conductivity

The parameters of interest for the HCC discharge are EC and TDS. Using the upper and lower ends of the range of secondary MCLs, isocontour maps of EC measurements were developed for both the unconfined and semi-confined aquifers as shown on Figures 10 and 11.

Unconfined Aquifer: In the unconfined aquifer, elevated EC measurements occur in wells within the area underlying the Primary Lands (Figure 10). The highest EC measurements of 4,000 µmhos/cm are noted in Wells MW-1 and MW-7 along the Primary Lands bordering the HCC facility. The lowest EC measurement in the Primary Lands area is 800 µmhos/cm in Well MW-10 along the northwestern border. In general, higher EC measurements are associated with wells screened above 20 feet bgs, and somewhat lower EC measurements are associated with wells screened in the lower portions of the unconfined aquifer, indicating some vertical differentiation within the unconfined aquifer.

The contour intervals of 900 and 1,600 µmhos/cm are shown in Figure 10 to represent the extent of the lower and upper range of secondary MCL values. Areas of groundwater with EC values greater than 900 and 1,600 µmhos/cm extend beyond the Primary Lands to the south and west (Figure 10). The projected surface area overlying groundwater with EC values above 1,600 µmhos/cm extending beyond the Primary Lands is estimated to be 160 acres, and the area overlying groundwater with EC values above 900 µmhos/cm extending beyond the Primary Lands is estimated at 240 acres. Of these land areas, approximately 75% or 70%, respectively, are owned either directly by HCC or the owners of HCC.

HCC's discharge to the Primary Lands appears to have contributed to creation of an area of groundwater with elevated levels of EC/TDS. Impacts attributable to HCC's discharge are largely confined to areas owned by HCC and HCC owners.

Of the water supply wells sampled (Brown and Caldwell, 2005a), six wells have EC measurements above the secondary MCL of 1,600 µmhos/cm. These include Wells DW-27, DW-35, DW-35B, DW-52, IW-4, and IW-7. Of these six wells, three (Wells DW-27, DW-52, and IW-4) are owned by HCC owners (Table 1). The three wells not owned by HCC or HCC owners are located on the margins of the Primary Lands.

It is noted that the EC isocontours generally parallel Lateral No. 6. Lateral No. 6 is concrete lined but may still have minor leakage along joints or cracks. This may reflect localized influence of minor leakage from Lateral No. 6 on the shallow groundwater and have the effect of limiting elevated EC levels primarily to the south of the lateral. This influence was not noted on the groundwater elevations maps, so it is likely a localized occurrence, if it does occur.

An area of groundwater with EC measurements above 900 µmhos/cm is observed to the north of the HCC facility that is interpreted to represent groundwater impact from a separate source area not related to HCC's discharge (Figure 10). The three wells near this location have EC measurements ranging from 990 to 1,100 µmhos/cm. This area is not fully defined so the location and magnitude of the groundwater impacts from this other source cannot be fully determined.

The lowest EC measurement of 310 µmhos/cm is found in Well MW-20 southwest of the site. This well and other wells in the area surrounding the HCC property may reflect contributions from irrigation of fields with TID water, which has a historic average EC of 154 µmhos/cm. Two fairly large areas near Well MW-20 are indicated as cropped fields and are irrigated with TID water when available.

Semi-Confined Aquifer: In the semi-confined aquifer, EC measurements in groundwater beneath the site are significantly lower than those observed in the shallower unconfined aquifer. Of the domestic wells screened in this aquifer zone, only the sample, from Well DW-23, had an EC measurement of 1,600 µmhos/cm. An area of EC measurements above 900 µmhos/cm is shown along the southern and western margin of the Primary Lands that represents downward migration from the unconfined aquifer. Within this aquifer zone, the area of groundwater with elevated EC is elongated along a northwest-southeast axis. This is interpreted to represent the influence of groundwater withdrawal from extraction, including the operation of HCC wells, pulling groundwater in these directions.

The projected surface area above groundwater in the lower semi-confined aquifer zone with EC values above 1,600 µmhos/cm and extending beyond the Primary Lands is estimated at approximately 10 acres, and the area above groundwater with EC measurements above 900 µmhos/cm extending beyond the Primary Lands is estimated at 80 acres. Approximately 100% or 75%, respectively, of these land areas is either owned directly by HCC or the owners of HCC.

In the semi-confined aquifer, EC measurements for samples from four wells located immediately upgradient of the site (Wells IW-21, DW-38, DW-38B, and DW-40) range from 510 to 860 µmhos/cm (Figure 11). The area of groundwater with elevated EC measurements is significantly smaller than in the overlying unconfined zone. Our evaluation indicates that only minor impacts have occurred in the semi-confined aquifer due to discharge of wastewater with EC values over 900 µmhos/cm.

Two areas of groundwater with EC measurements exceeding 900 µmhos/cm are noted on Figure 11 that are interpreted to represent effects to the semi-confined aquifer from separate source areas not related to HCC. Samples from two wells northwest of the site, Wells DW-19 and DW-20, have EC measurements of 940 and 980 µmhos/cm, respectively. Samples from two wells south and southeast of the site, Wells DW-64 and DW-104, have

EC measurements of 1,300 and 1,100 µmhos/cm, respectively. Because of the distances involved and the presence of intervening areas of groundwater with lower EC values, these are interpreted to represent two areas of groundwater impacted by sources separate from HCC that are comparable or larger than the area impacted by HCC. The areas extend beyond the area included in the recent water supply well sampling program, therefore, the extent of groundwater impacts from these other sources cannot be fully characterized with the available data.

Cross Sections: The EC measurements have been superimposed onto three geologic cross sections to illustrate the vertical extent of the groundwater area with elevated EC (Figures 12, 13 and 14). Based upon the available data, dissolved inorganic constituents resulting in elevated EC values are generally concentrated in the shallow portion of the unconfined aquifer between 0 and 20 feet bgs. The lower portion of the unconfined aquifer at depths between approximately 20 and 75 feet bgs has groundwater with EC measurements above the 900 to 1,600 µmhos/cm over portions of the site.

In general, the semi-confined aquifer occurring at depths of approximately 75 to 125 bgs shows significantly less impact associated with HCC's discharge. The Corcoran Clay is thick, low-permeability confining layer, and the older alluvium below the Corcoran Clay is not considered to be impacted by EC.

Cross Section A-A' parallels Lander Avenue along the eastern border of the site. On Cross Section A-A' (Figure 12), the area of groundwater with elevated EC values is restricted to the unconfined aquifer. In the vicinity of Well MW-4, a sand and gravel sequence has allowed for more vertical mixing within the unconfined aquifer. However, the semi-confining layers appear to be limiting the downward migration into the semi-confined aquifer.

Cross Section B-B' parallels August Road along the southern border of the site. Along this cross-section, the EC measurements are highest in the shallowest portion of the unconfined aquifer. Impacts to the semi-confined aquifer are noted but are of much smaller magnitude than those in the shallower zone (Figure 13). The geologic conditions appear to effectively limit the vertical distribution of EC to the zone above the semi-confined aquifer, which is the primary water-producing horizon. To the west, higher concentrations are noted in the lower portion of the unconfined zone that are likely due to induced migration from groundwater pumping.

Cross Section C-C' parallels Columbus Avenue west of the site (Figure 14). EC measurements in the upper portion of the unconfined aquifer on Cross Section C-C' are lower than those observed showing that the horizontal extent of groundwater with elevated EC is more limited at this downgradient location. This is likely due to attenuation mechanisms including advection, dispersion, and percolation of lower salinity water from the surface. EC measurements in the lower portion of the unconfined aquifer and in the semi-confined aquifer are also likely due to induced migration from groundwater pumping.

3.5.3 Distribution of Total Dissolved Solids

Using the upper and lower ends of the range of secondary MCLs, isoconcentration maps of total dissolved solids (TDS) were developed for both the unconfined and semi-confined aquifers as shown on Figures 15 and 16.

Unconfined Aquifer: The TDS isoconcentration maps for the uppermost aquifer zones show a pattern very similar to those from the EC measurement isocontours. The highest TDS concentrations of 2,400 mg/L are noted in Wells MW-1, MW-7 and MW-13. The lowest TDS concentration in groundwater within the Primary Lands is 510 mg/L in Well MW-10 along the northwestern border. In general, TDS concentrations are higher in wells completed at depths above 20 feet bgs than in those wells screened in the lower portions of the unconfined aquifer, indicating some vertical differentiation within the unconfined aquifer.

Of the water supply wells sampled, seven wells have TDS concentrations above the secondary MCL of 1,000 mg/L. These include Wells DW-27, DW-28, DW-35, DW-35B, DW-52, IW-4, and IW-7. Of these seven wells, four (Wells DW-27, DW-28, DW-52, and IW-4) are owned by HCC owners (Table 1). The three wells not owned by HCC or HCC owners are located on the margins of the Primary Lands.

The distribution and horizontal extent of TDS in groundwater shows good agreement with the EC isocontour maps. As expected, the horizontal extent of TDS is comparable to that of the EC measurements. A similar area of increased TDS is noted north of the site that is interpreted to represent an offsite source.

Semi-Confined Aquifer: In the semi-confined aquifer, the TDS concentrations in groundwater beneath the site are significantly lower than those observed in the overlying unconfined aquifer. This confirms that the subsurface physical conditions appear to effectively limit the vertical migration of EC/TDS constituents into this water-producing horizon.

TDS concentrations greater than 1,000 mg/L were not observed in samples from wells screened in the semi-confined aquifer. The highest observed concentrations are 990 mg/L in Well DW-23 northwest of the site and 960 mg/l in Well DW-64 south of the site. The elevated TDS concentrations in Well DW-64 are interpreted to represent the influence of a source area not associated with HCC's discharge.

The area of 500 mg/L TDS concentrations further confirms the limited impact to groundwater to the semi-confined aquifer. The distribution of the 500 mg/L contour does not a show an area of elevated concentration beneath the site, but rather shows a more general distribution. This is interpreted to signify that 1) the background concentrations of TDS are higher in the semi-confined zone, and 2) the limited impact from the HCC facility essentially blends into the existing TDS concentrations in the semi-confined aquifer.

3.5.4 Distribution of Sodium and Chloride

Sodium and chloride have been identified by the RWQCB as the components in HCC's discharge contributing most to potential impacts to salt-sensitive crops. The RWQCB (2004) listed lower and upper range of salt sensitivity for sodium of 69 and 106 mg/L and chloride

(106 and 175 mg/L). The lower range number is from Ayers and Westcott (1985) and the upper range is from ASCE (1996).

The overall distribution of sodium and chloride in the unconfined aquifer correlates with that of EC and TDS measurements. The highest concentrations are observed in groundwater below the Primary Lands. Sodium and chloride concentrations above their respective salt sensitivity criteria extend beyond the Primary Lands to the south and west. Samples from Well DW-28 had lower concentrations of both sodium and chloride, suggesting that Well DW-28 is being impacted by activities other than wastewater discharge from HCC.

Well IW-4 is located in an area that is shown on the land use map (Figure 4) as growing tree nuts, which is the only moderately salt-sensitive crop grown within the vicinity of the facility. however the tree nuts on the parcel are reportedly irrigated with water from TID. This property is owned by Kathy and Delton Nyman, co-owners of HCC.

The area used for growing tree nuts shown on Figure 4 to the east of the site is upgradient of the HCC facility and has not been impacted by HCC's discharge.

The highest sodium and chloride concentrations in the semi-confined zone are found south of the site in Wells IN-9 and DW-104. These wells are interpreted to represent groundwater impact from a separate source area not related to HCC.

Section 4: Extent of Groundwater Impact

Our evaluation of the available data from HCC's extensive past and ongoing groundwater monitoring program and additional sampling of nearby water supply wells indicates that application of wastewater to the Primary Lands has resulted in an area of shallow groundwater with increased inorganic salinity content as reflected in EC and TDS measurements. The constituents reflected in the EC/TDS measurements are not toxic and do not represent a direct threat to human health or wildlife. The proposed financial penalty in the ACLC is not commensurate with the extent of impacts to shallow groundwater, nor does it appear to consider HCC's extensive efforts to comply with the permit conditions.

Figure 17 illustrates a three-dimensional (3-D) representation of the distribution of EC/TDS in groundwater beneath the site, based on a combination of analytical data and computer-modeled (Appendix F) information. The shaded area represents the approximate zone of groundwater with EC values above the upper secondary MCL value of 1,600 µmhos/cm. Groundwater with EC values/TDS concentrations above the upper range of the secondary MCLs, is confined to a shallow dish-shaped lens that is primarily present in the unconfined shallow groundwater zone. The area of elevated TDS concentration extends beyond the HCC facility only in the southeast portion of the study area. The area of groundwater with elevated EC/TDS present in the deeper semi-confined aquifer zone is much smaller in extent and the shape roughly resembles a tapered lens or dish.

The extent of the zone of affected groundwater is such that groundwater with higher salinity has not significantly impacted the zone where most of the domestic supply wells are screened. The impacts appear to be limited more to the uppermost aquifer zone. This may be partly due to the more impervious nature of the older alluvium below the uppermost aquifer. Mixing with upgradient groundwater arriving at the HCC site provides the primary mechanism for attenuation of the groundwater with elevated TDS concentrations.

Groundwater EC measurements and TDS concentrations exceeding the respective secondary MCL values extend south and west of the Primary Lands. However, this area extending beyond the Primary Lands is limited to an estimated 160 acres with respect to the upper range MCL values, and an estimated 240 acres with respect to the lower range MCL values.

Limited downgradient migration is noted, and several attenuation mechanisms appear to limit the southwestward migration of EC and TDS in shallow groundwater. These attenuation mechanisms include: 1) advection and dispersion related to the mechanics of groundwater flow, and 2) the influx of lower salinity water from the percolation of irrigation return flow, precipitation, and Lateral No. 6 leakage.

The vertical extent of the EC and TDS impact to groundwater is limited. The semi-confined aquifer, which is the primary source of drinking water and agricultural water supply, is far less impacted. The natural geologic conditions, as evidenced by the noted hardpan layers, have proved sufficient in limiting the migration of salts into the deeper aquifers, and attenuation mechanisms are present that limit the vertical migration of the salt.

Data from HCC's groundwater monitoring wells and the nearby water supply wells indicate that the lateral and vertical extent of EC and TDS impact to groundwater is limited. Moreover, much of the property overlying the shallow groundwater with elevated EC/TDS is owned by co-owners of HCC. The financial penalty proposed in the ACLC is inconsistent with the limited extent of the EC and TDS impact to groundwater. Moreover, the proposed penalty does not reflect that the impacted groundwater is largely beneath lands controlled either directly by HCC or the owners of HCC.

Section 5: Gravity

The gravity of the impacts to groundwater from inorganic constituents in HCC's discharge is minimal. Several of the factors limiting the gravity have been mentioned previously and include:

- the wastewater constituents are not toxic and do not endanger human health or wildlife
- the EC and TDS impact is limited in both horizontal and vertical extent
- the area of elevated EC measurement/TDS concentration in groundwater is largely confined to HCC's property or to lands owned by HCC's owners
- only very limited EC and TDS impacts are observed in the semi-confined aquifer which is the more significant source of groundwater supply in the area

EC and TDS do not pose an immediate or direct threat to human health or the environment. Salt is a constituent of much lesser concern for human health than toxic chemicals (e.g., gasoline, VOCs, perchlorate, etc.) which have impacted shallow groundwater in many areas of California. Users of domestic supply wells in the vicinity of HCC's facility who have expressed concern regarding their drinking water quality have been offered bottled water at HCC's expense.

The shallow groundwater with increased salinity levels may impact salt-sensitive agricultural crops if used for irrigation purposes. The area overlying groundwater with elevated EC/TDS concentrations is limited to approximately 160 - 240 acres south and west of the Primary Lands. A 30-acre area of tree nuts located southwest of the site is the only area of salt-sensitive crops potentially impacted by HCC's land application activities. However, this land is irrigated with TID supply water owned by Kathy and Delton Nyman, co-owners of HCC, and the property is reportedly irrigated with TID water. Other areas of tree nuts are located upgradient of the HCC site and are unaffected by HCC's land application activities.

Approximately 75 percent of the acreage beyond the Primary Lands that is underlain by groundwater with EC/TDS above the upper range secondary MCL is either owned directly by HCC or by the owners of HCC.

Data from the water supply well sampling event shows evidence of groundwater impacts from sources other than HCC that are of comparable or greater magnitude than those from the HCC facility just within the area of one-half mile of the HCC site. This indicates that the groundwater in the site vicinity has been impacted by various sources. Therefore, the gravity of the groundwater impact from HCC's land application activities is comparable to, or potentially less significant than, other sites in the area that have not been identified, investigated, or issued ACL Complaints.

Based on this assessment, the gravity of the groundwater impact from HCC is considered to be minimal. The gravity of the EC impact does not support the financial penalty proposed in the ACLC.

Section 6: Toxicity

The issues relative to the shallow groundwater with increased salinity include potential effects on domestic and agricultural supply beneficial uses.

With respect to domestic water supply, EC and TDS are parameters for which there are no Primary MCLs, but secondary MCLs have been established for aesthetic reasons. It is important to note that the HCC effluent wastewater does not render groundwater unusable due to the presence of toxic chemicals such as volatile organic compounds (VOCs), perchlorate, methyl tertiary butyl ether (MTBE) that are known carcinogens, pathogens, or endocrine disruptors. TDS and EC are not considered hazardous constituents, nor are they considered to be characteristic of hazardous, medical, or biological waste. At the concentrations found in the shallow groundwater, TDS, sodium and chloride are not toxic and are not a threat to human health or wildlife.

The potential effects of impacts from HCC's discharge pertain to increases in inorganic salts in soil and groundwater and the associated potential impact on production of salt-sensitive crops. Kennedy/Jenks assessed whether irrigation with water containing salinity at concentrations typical of those within the area of affected groundwater could have an adverse impact on crops. HCC's WDR permit refers to the U.S. Department of Food and Agriculture guidelines describing use of water for irrigation with EC values of up to 1,000 µmhos/cm as being considered "good to excellent" quality. This implicitly recognizes that water with EC values up to and beyond this level would be appropriate for agricultural use. The general impact of salinity in agriculture is expressed in the Food and Agriculture Organization's (FAO's) Irrigation and Drainage Paper 29, Revision 1, Water Quality for Agriculture (Ayers and Westcott 1994):

> Irrigation water contains a mixture of naturally occurring salts. Soils irrigated with this water will contain a similar mix but usually at a higher concentration than in the applied water. The extent to which the salts accumulate in the soil will depend upon the irrigation water quality, irrigation management and the adequacy of drainage. If salts become excessive, losses in yield will result.

The concentration at which salts become "excessive" is dependent on a variety of conditions, including the specific salt ions present, soil type, depth of the water table, climate, crop species, and irrigation management practices. In the area of HCC's facility, the tile drain systems were developed to lower the groundwater table below the root zone of the crops. The sandy soils in the Hilmar area are well drained which helps prevent the accumulation of salts in the root zone. In addition, typical irrigation practice in the area is to use imported surface water from the Tuolumne River provided by the TID rather than groundwater. These physical factors and management practices all contribute to lessen any potential impact of salinity in groundwater to locally-grown crop species.

Crops have varying tolerance to salts. Some crops can produce acceptable yields at much higher salinities than others due to plant mechanisms that regulate osmotic pressure. To evaluate whether other salt-sensitive crops would be grown within a broader radius of the HCC facility, the 2004 Crop Report for Merced County was reviewed. This provides an understanding of the most likely local crops. The top twelve agricultural commodities in Merced County (on a value basis) and their associated acreages and salt tolerance ratings are listed in Table 2.

As shown on Figure 4, the land uses in the vicinity of the HCC facility include agricultural (row crops, tree nuts), dairy operations and limited residential occupancy. We understand that the primary crops grown in the immediate vicinity of the HCC facilities include corn (silage), oats (silage) and alfalfa (grazing). On the rating scale developed by Ayers and Westcott (1994), silage was not rated, but forage corn, forage oats and alfalfa were all considered moderately sensitive to salinity. At the salinity levels in shallow groundwater if it were used for irrigating these crops, the only potential effects, if any, would be minimal decreases in yield.

Most of the tree nuts - the majority of which are almonds, which are identified in Ayers and Westcott as a salt-sensitive crop, are grown on lands east (generally upgradient) of the HCC facility. The only exception is an approximately 30-acre area southwest of the Primary Lands. This property is reportedly irrigated by TID supply water and belongs to co-owners of HCC.

Salt-sensitive crops are not being impacted by HCC's land application activities. Human health and wildlife are not threatened by the EC and TDS concentrations present in groundwater. The penalty amount proposed in the ACLC is disproportionate to the minimal toxicity of the constituents of interest (TDS and EC) in groundwater beneath and immediately downgradient of the HCC site.

Section 7: Susceptibility to Cleanup and Abatement

Mitigation measures already implemented by HCC include provision of bottled water for concerned nearby residents whose supply wells could be potentially impacted by elevated EC and TDS associated with HCC's discharge.

Salinity in groundwater is susceptible to cleanup through either active or passive remediation strategies. Based on our evaluation of the limited extent of impacts to groundwater and the fact that the impacts are limited to increased salinity, active cleanup measures appear unwarranted. Passive cleanup occurs through natural attenuation, primarily via advection and dispersion of the salts in the groundwater. The data indicate that several natural attenuation mechanisms are already occurring and are serving to limit the extent of elevated EC and TDS in groundwater around the HCC site. HCC's ongoing measures to decrease the mass loading of salinity in the discharge through source reduction and treatment will result in further abatement.

Active cleanup would require extraction of the groundwater and removal of the salts using an aboveground treatment system, with the removed salts transported to an offsite location for further management. This would require extraction of large volumes of groundwater, which could potentially interfere with the beneficial use of groundwater by the water users in the vicinity of the site and also engenders additional environmental impacts associated with energy usage and transportation.

A significant penalty may be appropriate for impacts to groundwater that are toxic, permanent in nature and/ or not susceptible to abatement. The penalty proposed in the ACLC is not commensurate with the extent of impact to shallow groundwater and susceptibility to abatement. The resources contemplated by the proposed fine could be more beneficially invested by HCC to improve the effectiveness and reliability of the existing process wastewater management system.

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Tables

Table 1: Recent Sampling Data and Information for HCC Monitoring Wells and Nearby Water Supply Wells

Well ID	Well Type	HCC-owned or HCC-owner-owned Wells	Perforated Zone (feet bgs)	Groundwater Unit	Groundwater Unit Assignment Basis	Date	Electrical Conductivity (µmhos/cm)[a]	Total Dissolved Solids (mg/l)[b]
MW-1	Monitoring Well	x	10-20	Unconfined Aquifer	Perforated Zone	3/9/2005	4000	2400
MW-2	Monitoring Well	x	10-20	Unconfined Aquifer	Perforated Zone	3/9/2005	2900	1700
MW-3B	Monitoring Well	x	10-20	Unconfined Aquifer	Perforated Zone	3/9/2005	2000	1300
MW-4	Monitoring Well	x	10-20	Unconfined Aquifer	Perforated Zone	3/9/2005	1000	730
MW-5	Monitoring Well	x	10-20	Unconfined Aquifer	Perforated Zone	3/8/2005	2600	1600
MW-6	Monitoring Well	x	10-20	Unconfined Aquifer	Perforated Zone	3/9/2005	2600	1800
MW-7	Monitoring Well	x	10-20	Unconfined Aquifer	Perforated Zone	3/9/2005	4000	2400
MW-8	Monitoring Well	x	10-20	Unconfined Aquifer	Perforated Zone	3/8/2005	2300	1400
MW-9	Monitoring Well	x	10-20	Unconfined Aquifer	Perforated Zone	3/8/2005	3100	2100
MW-10	Monitoring Well	x	10-20	Unconfined Aquifer	Perforated Zone	3/8/2005	800	510
MW-11	Monitoring Well	x	10-20	Unconfined Aquifer	Perforated Zone	3/9/2005	1100	730
MW-12	Monitoring Well	x	10-20	Unconfined Aquifer	Perforated Zone	3/8/2005	830	680
MW-13	Monitoring Well	x	10-20	Unconfined Aquifer	Perforated Zone	3/9/2005	3700	2400
MW-14	Monitoring Well	x	10-20	Unconfined Aquifer	Perforated Zone	3/8/2005	1900	1400
MW-15	Monitoring Well	x	10-20	Unconfined Aquifer	Perforated Zone	3/8/2005	2000	1200
MW-16	Monitoring Well	x	10-20	Unconfined Aquifer	Perforated Zone	3/8/2005	890	700
MW-17	Monitoring Well	x	10-20	Unconfined Aquifer	Perforated Zone	3/8/2005	550	430
MW-18	Monitoring Well	x	50-60	Unconfined Aquifer	Perforated Zone	3/9/2005	850	660
MW-19	Monitoring Well	x	50-60	Unconfined Aquifer	Perforated Zone	3/8/2005	950	710
MW-20	Monitoring Well	x	10-20	Unconfined Aquifer	Perforated Zone	3/9/2005	310	270
DW-1	Domestic Well		--	Unconfined Aquifer	Inferred	5/26/2005	610	430
DW-5	Domestic Well		--	Semi-Confined Aquifer	Inferred	5/11/2005	530	370
DW-6	Domestic Well		--	Semi-Confined Aquifer	Inferred	5/11/2005	800	560
DW-7	Domestic Well		--	Unconfined Aquifer	Inferred	5/17/2005	990	640
DW-7A	Domestic Well		--	Unconfined Aquifer	Inferred	5/17/2005	1100	850
DW-8	Domestic Well		--	Semi-Confined Aquifer	Inferred	5/17/2005	730	530
DW-10	Domestic Well		280-300	Confined Aquifer	Perforated Zone	5/11/2005	590	340
DW-12	Domestic Well		61-71	Unconfined Aquifer	Perforated Zone	5/12/2005	620	440
DW-18	Domestic Well		--	Semi-Confined Aquifer	Inferred	5/12/2005	740	490
DW-19	Domestic Well		--	Semi-Confined Aquifer	Inferred	5/12/2005	940	630
DW-20	Domestic Well	x	--	Semi-Confined Aquifer	Inferred	6/1/2005	980	680
DW-21	Domestic Well		75-95	Semi-Confined Aquifer	Perforated Zone	5/25/2005	740	480
DW-23	Domestic Well		80-100	Semi-Confined Aquifer	Perforated Zone	5/5/2005	1600	990
DW-24	Domestic Well		106-126	Semi-Confined Aquifer	Perforated Zone	5/5/2005	1000	680
DW-25	Domestic Well		--	Unconfined Aquifer	Inferred	5/5/2005	860	650
DW-27	Domestic Well	x	60-80	Unconfined Aquifer	Perforated Zone	5/3/2005	1700	1100

Table 1: Recent Sampling Data and Information for HCC Monitoring Wells and Nearby Water Supply Wells

Well ID	Well Type	HCC-owned or HCC-owner-owned Wells	Perforated Zone (feet bgs)	Groundwater Unit	Groundwater Unit Assignment Basis	Date	Electrical Conductivity (µmhos/cm)[(a)]	Total Dissolved Solids (mg/l)[(b)]
DW-28	Domestic Well	x	--	Unconfined Aquifer	Inferred	5/4/2005	1500	1100
DW-29	Domestic Well		95-115	Semi-Confined Aquifer	Perforated Zone	5/19/2005	790	570
DW-29A	Domestic Well		115-125	Semi-Confined Aquifer	Perforated Zone	5/19/2005	770	540
DW-31	Domestic Well		102-110	Semi-Confined Aquifer	Perforated Zone	5/12/2005	1000	640
DW-34	Domestic Well	x	75-95	Semi-Confined Aquifer	Perforated Zone	5/3/2005	1200	750
DW-35	Domestic Well		--	Unconfined Aquifer	Inferred	5/13/2005	1800	1100
DW-35B	Domestic Well		--	Unconfined Aquifer	Inferred	5/13/2005	2000	1200
DW-38	Domestic Well		90-110	Semi-Confined Aquifer	Perforated Zone	5/13/2005	770	510
DW-38B	Domestic Well		--	Semi-Confined Aquifer	Inferred	5/13/2005	700	460
DW-40	Domestic Well		90-110	Semi-Confined Aquifer	Perforated Zone	5/12/2005	860	560
DW-43	Domestic Well		--	Semi-Confined Aquifer	Inferred	5/6/2005	730	520
DW-44	Domestic Well		90-110	Semi-Confined Aquifer	Perforated Zone	5/19/2005	780	520
DW-47	Domestic Well		--	Unconfined Aquifer	Inferred	5/26/2005	550	390
DW-50	Domestic Well	x	--	Semi-Confined Aquifer	Inferred	5/4/2005	810	570
DW-52	Domestic Well	x	--	Unconfined Aquifer	Inferred	5/4/2005	1800	1100
DW-53	Domestic Well		175-195	rcoran Clay Confining La	Perforated Zone	5/25/2005	590	410
DW-54	Domestic Well		230-250	Confined Aquifer	Perforated Zone	5/17/2005	280	170
DW-55	Domestic Well		76-116	Semi-Confined Aquifer	Perforated Zone	5/11/2005	790	530
DW-58	Domestic Well		--	Unconfined Aquifer	Inferred	5/18/2005	1100	730
DW-59	Domestic Well		--	Semi-Confined Aquifer	Inferred	5/19/2005	640	420
DW-60	Domestic Well		--	Unconfined Aquifer	Inferred	5/18/2005	890	680
DW-62	Domestic Well		90-100	Semi-Confined Aquifer	Perforated Zone	5/26/2005	450	280
DW-63	Domestic Well		--	Semi-Confined Aquifer	Inferred	5/25/2005	690	440
DW-64	Domestic Well		--	Semi-Confined Aquifer	Inferred	5/4/2005	1300	960
DW-65	Domestic Well	x	75-105	Semi-Confined Aquifer	Perforated Zone	5/3/2005	1000	690
DW-68	Domestic Well		220-260	Confined Aquifer	Perforated Zone	5/6/2005	270	170
DW-69	Domestic Well	x	220-240	Semi-Confined Aquifer	Perforated Zone	5/3/2005	1000	630
DW-79	Domestic Well		95-115	Semi-Confined Aquifer	Perforated Zone	5/6/2005	780	520
DW-97	Domestic Well		90-110, 160-190	Semi-Confined Aquifer	Perforated Zone	5/19/2005	800	570
DW-99	Domestic Well		88-108	Semi-Confined Aquifer	Perforated Zone	5/5/2005	700	510
DW-101	Domestic Well		85-105	Semi-Confined Aquifer	Perforated Zone	5/25/2005	740	490
DW-102	Domestic Well		100-120	Semi-Confined Aquifer	Perforated Zone	5/26/2005	720	480
DW-103	Domestic Well	x	100-120	Semi-Confined Aquifer	Perforated Zone	5/4/2005	820	550
DW-104	Domestic Well		85-105	Semi-Confined Aquifer	Perforated Zone	5/5/2005	1100	720
DW-105	Domestic Well		100-120	Semi-Confined Aquifer	Perforated Zone	5/11/2005	510	350
DW-106	Domestic Well		120-140	Semi-Confined Aquifer	Perforated Zone	5/27/2005	630	400

Table 1: Recent Sampling Data and Information for HCC Monitoring Wells and Nearby Water Supply Wells

Well ID	Well Type	HCC-owned or HCC-owner-owned Wells	Perforated Zone (feet bgs)	Groundwater Unit	Groundwater Unit Assignment Basis	Date	Electrical Conductivity (µmhos/cm)[(a)]	Total Dissolved Solids (mg/l)[(b)]
DW-10180	Domestic Well		--	Unconfined Aquifer	Inferred	5/18/2005	1100	810
DW-C	Domestic Well		--	Semi-Confined Aquifer	Inferred	5/4/2005	740	520
IN-1	Industrial Well	x	80-95, 210-235	Semi-Confined Aquifer	Perforated Zone	5/2/2005	970	600
IN-2	Industrial Well	x	100-130, 225-245	Semi-Confined Aquifer	Perforated Zone	5/2/2005	1000	610
IN-3	Industrial Well		230-250	Confined Aquifer	Perforated Zone	5/17/2005	780	550
IN-4	Industrial Well		170-190	Unconfined Aquifer	Perforated Zone	5/18/2005	660	390
IN-5	Industrial Well		205-245	Confined Aquifer	Perforated Zone	5/19/2005	440	250
IN-7	Industrial Well	x	340-380	Confined Aquifer	Perforated Zone	5/5/2005	1000	620
IN-9	Industrial Well		110-130	Semi-Confined Aquifer	Perforated Zone	5/25/2005	840	500
IW-3	Irrigation Well	x	--	Semi-Confined Aquifer	Inferred	5/3/2005	1000	700
IW-4	Irrigation Well	x	135-155	Unconfined Aquifer	Questionable	5/3/2005	2200	1400
IW-17	Irrigation Well		0-112	Unconfined Aquifer	Inferred	6/1/2005	2000	1300
IW-19	Irrigation Well	x	85-105	Semi-Confined Aquifer	Perforated Zone	5/3/2005	820	560
IW-20	Irrigation Well		--	Unconfined Aquifer	Inferred	6/1/2005	1500	940
IW-21	Irrigation Well		--	Semi-Confined Aquifer	Inferred	6/1/2005	540	390
IW-22	Irrigation Well		--	Semi-Confined Aquifer	Inferred	6/1/2005	790	540

Notes:
Information obtained from Brown and Caldwell 2005a, 2005b and 2005c.

(a) µmhos/cm = micromhos per centimeter
(b) mg/l = milligrams per liter

Table 2: Salt Sensitivity and Acreage of Merced County Crops

Commodity	Acreage[a]	Salt Tolerance[b]
1. Milk	n/a[c]	n/a
2. Almonds	86,382	Sensitive
3. Chickens	n/a	n/a
4. Cattle and calves	n/a	n/a
5. Tomatoes	15,900	Mod. Sensitive
6. Cotton	69,205	Tolerant
7. Sweet potatoes	10,084	Mod. Sensitive
8. Hay (alfalfa)	79,481	Mod. Sensitive
9. Eggs, chicken	n/a	n/a
10. Turkeys	n/a	n/a
11. Silage (corn)	75,810	Mod. Sensitive[d]
12. All nursery products	1,920	n/a

(a) From Merced County 2004 Crop Report
(b) From Ayers and Wescott, 1994
(c) n/a = not available
(d) Rating provided for forage corn