THE BOARD OF SUPERVISORS OF THE COUNTY OF STANISLAUS
ACTION AGENDA SUMMARY

DEPT: Environmental Resources **BOARD AGENDA #** B-10

Urgent ☐ **Routine** ■ **AGENDA DATE** September 29, 2009

CEO Concurs with Recommendation YES ☐ **NO** ☐ **(Information Attached)** **4/5 Vote Required YES** ☐ **NO** ■

SUBJECT:

Update on the Food Processing By-products Use Program

STAFF RECOMMENDATIONS:

Accept the Food Processing By-product Use Program update.

FISCAL IMPACT:

There is no fiscal impact associated with receiving an update on the Food Processing By-product Use Program.

BOARD ACTION AS FOLLOWS:

No. 2009-658

On motion of Supervisor Chiesa, **Seconded by Supervisor** Grover
and approved by the following vote,
Ayes: Supervisors: O'Brien, Chiesa, Grover, Monteith, and Chairman DeMartini
Noes: Supervisors: None
Excused or Absent: Supervisors: None
Abstaining: Supervisor: None

1) X **Approved as recommended**
2) ____ **Denied**
3) ____ **Approved as amended**
4) ____ **Other:**
MOTION:

ATTEST: **CHRISTINE FERRARO TALLMAN, Clerk** **File No.**

DISCUSSION:

Background Information

The Stanislaus County Food Processing By-product Use Program (Program) has effectively controlled nuisance conditions for more than 30 years while facilitating the reuse of a valuable agricultural commodity; largely soil amendments and animal feed. Combined efforts of the agricultural community, local and state public agencies, private industry, by-product haulers, and permitted site operators have contributed to the success of the Program. The Department of Environmental Resources (Department) has promoted the Program as also being protective of water quality; a view that was not originally shared by the Regional Water Quality Control Board (RWQCB). Specifically, the Department was required to provide data to the RWQCB, described in a *Tentative Resolution Regarding Reuse of Food Processing Byproducts* and in the adopted *Resolution Regarding Reuse of Food Processing Byproducts* (Resolution), issued to the Department in June 2006, as a means of supporting this position.

The Resolution allowed the Department to continue the Program while performing a literature review and technical research study to evaluate the possibility of potential impacts to water quality as a result of by-product land application. All required submittals were completed and provided to the RWQCB by the assigned due dates. The final requirement of the Resolution was to adopt an Ordinance or other legal mechanism to provide for implementation and enforcement of the Program. The Board of Supervisors adopted Stanislaus County Ordinance, Chapter 9.88 (Ordinance), and associated *Regulations for the Use of Food Processing By-Products in Stanislaus County by Permitted Use Sites* and the *Manual of Best Practices for Application of Food Processing By-products on Farmlands* (Regulations), on February 26, 2008.

As the result of meeting the requirements of the Resolution, the Department recently received the *Approval of Food Processing By-products Use Program Pursuant to Resolution No. R5-2008-0182, County of Stanislaus Environmental Resources Department* letter dated June 8, 2009, from the RWQCB, Central Valley Region (Attachment "A"). This correspondence affirms that Stanislaus County manages food processing by-products so that they can be "beneficially used in an environmentally sound manner," and qualifies all permitted Program sites to be included under a Waiver of Reports of Waste Discharge and Waste Discharge Requirements for Specific Types of Discharge within the Central Valley Region of the RWQCB.

The Department will continue to administer the Program pursuant to the Ordinance, as well as the RWQCB *Agreement for Monitoring and Reporting of Solid and Semi-Solid Food Processing By-Products Applied under the Stanislaus County Program*. This accomplishment was made possible due to the collaborative efforts of Department staff, by-product site operators, local food processors, and the California State University (CSU), Fresno Foundation research team (Foundation). The sources of funding support for the Foundation are as follows: California Department of Food and Agriculture

Specialty Crop Grant and Stanislaus County for Phase 1 research, and CSU-Agricultural Research Initiative and Stanislaus County for Phase 2 research.

Food Processing By-product Use Program Update

The Board was most recently updated on February 12, 2008, when the Department was awaiting final comment from the RWQCB on the Ordinance and the associated Regulations. It was noted at that time that data collection for the initial phase (Phase 1) of the research project was complete, and a second scope of work (Phase 2) would be performed in order to address identified data gaps. The data the Department was required to provide in order to gain Program approval, assuring that it was protective of nuisance conditions and water quality, was as follows:

Phase 1: Conducted by the Foundation, this portion of the research project focused on a literature review of existing data, analyzing by-product constituents, movement or lack of movement of those constituents through the soil profile, and the potential impacts to groundwater and surface water those constituents may pose, if identified. In addition to literature reviews of existing local and national data, Phase 1 studies included the following:

- A soil moisture probe field study
- An infiltration study
- A bench-scale loading rate study
- A nutrient management plan

The results of the soil moisture probe field study and the infiltration study were provided to the Department by Horacio Ferriz, Ph.D., P.G., in a report entitled, *Fluid Infiltration in Soils Used for Land Application of Food Processing Vegetable Byproducts* dated June 30, 2009 (Attachment "B"). The following summarizes the recommendations of the report:

- Managed irrigation could limit water propagation through the soil profile.
- Silty sands and sandy loam soils seem to have the lowest infiltration rates, and are recommended for land application.
- Measurement of infiltration rate may be considered when determining suitability of soil for land application of vegetable food processing by-products.
- Vegetable particles tend to seal soil pores, preventing the infiltration of by-products through the soil profile.

Observations and results for the bench-scale loading rate study were provided to the Department by Dr. Sajeemas (Mint) Pasakdee, Soil Scientist/Agronomist for the Foundation, in a memo with the subject heading, "Bench scale studies of peach by-products applied at various loading rates," dated January 20, 2009 (Attachment "C"). The following summarizes her conclusions:

• Application of peach by-products significantly increased macro- and micronutrients, and trace elements to sandy loam and silt loam soils.
• Contribution of salt from the by-products is minimal.
• Growers are expected to benefit economically from a reduction in the use of chemical fertilizer inputs with replacement of less expensive by-products.
• Considering annual elemental inputs from by-products, crop removal rates, crop selection, irrigation management, and proper site management, application of by-products on farmlands will pose minimal impacts to groundwater quality.

Lastly, the *Nutrient Management Plan for the Use of Food Processing By-Products as Soil Amendments* (Attachment "D") was provided to the Department by Dr. Pasakdee as an operational plan for the reuse of solid, semi-solid, and slurry food processing by-products in a manner that minimizes potential impacts to soil and water quality through practical and available management practices and technologies.

To address identified data gaps during Phase 1 of the research project, Phase 2 research has begun and will include the following research experiments:

- Crop nutrient balance field studies to advance knowledge regarding crop nutrient removal patterns
- Soil moisture content field studies after by-product application
- Field experiments to study loading rates, compare site conditions, and/or compare crop quality
- Modeling studies for irrigation water movement through lysimeters
- Modeling studies for salt/solute movement
- Review of previous relevant studies
- Revise the *Manual of Best Practices for Application of Food Processing By-products on Farmlands (Manual)*

On March 2, 2009, Dr. Ferriz provided a progress report (Attachment "E") including raw data from 20 lysimeter samples for the irrigation water movement and salt/solute movement studies. The analyses provide data on the content of Total-, Fixed-, and Volatile-Dissolved Solutes (TDS, FDS, and VDS, respectively) in food processing by-products and in infiltration waters. VDS ranges from 30 to 60% of TDS, but in processed fruit may be as high as 98%. Dr. Ferriz informed the Department that it is reasonable to assume the microorganisms in the soil would consume the VDS load and, therefore, the relevant parameter of focus would be FDS.

The Department received an additional progress report from Dr. Ferriz on May 11, 2009, for the irrigation water movement and salt/solute movement studies (Attachment "F"). Current data show that some salts adhere to clayey soils due to chemical attractions, while others do not. Further research is needed on the chemical behavior of salts/solutes to best understand how they travel through regular loamy soils and in alkaline sandy, clayey, and loamy soils. A six-month experiment with regular and alkaline loamy soils, both of which are soil types that are commonly found throughout the County, is underway as a part of this study. The importance of this evaluation is to find the balance and compromise between good hydraulic performance (physical behavior) and good geochemical performance (chemical behavior).

Finally, a revision of the *Manual,* dated June 29, 2007, will occur as a Phase 2 task and all work in this Phase will be completed on or before August 31, 2010. The remaining experiments in Phase 2 have are either in planning stages or are in progress at the time of this report.

POLICY ISSUE:

The Board should determine if accepting the update on the Food Processing By-products Use Program is consistent with its priorities of a strong agricultural community/heritage, a healthy community, effective partnerships, and a well-planned infrastructure system. Programs such as the reuse of food processing by-products also help the County meet mandated landfill diversion requirements.

STAFFING IMPACTS:

There are no staffing impacts associated with this item.

CONTACT PERSON:

Sonya K. Harrigfeld, Director. Telephone: 209-525-6770

California Regional Water Quality Control Board
Central Valley Region
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Arnold Schwarzenegger
Governor

JUN 2009
Received
Stanislaus Co.
Dept. Of
Environmental
Resources

8 June 2009

Sonya K. Harrigfeld, Director
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APPROVAL OF FOOD PROCESSING BY-PRODUCTS USE PROGRAM PURSUANT TO RESOLUTION NO. R5-2008-0182, COUNTY OF STANISLAUS ENVIRONMENTAL RESOURCES DEPARTMENT

On 22 June 2006, the Central Valley Regional Water Quality Control Board (Central Valley Water Board) adopted Resolution No. R5-2006-0052 (Resolution) allowing the County of Stanislaus to continue its Food Processing By-Products Use Program (Program) to divert solid and semi-solid food processing by-products from county landfills while completing technical studies to evaluate *"...the effects or threatened effects of food processing by-products on waters of the state and to help determine the appropriate regulatory mechanism for the discharge of food processing by-products on a County-wide or possibly Region-wide basis."*

The County's Program regulates the use of food processing by-products for use as a soil amendment, use as direct animal feed, dehydration, and composting operations. In the Resolution, the Central Valley Water Board found that the Program's requirements for direct animal feed were adequate to protect water quality, and dehydration and composting operations were more appropriately regulated outside the scope of the Resolution. Accordingly, the scope of the Resolution is specific to the use of food processing by-product waste as a soil amendment.

The County of Stanislaus submitted the following technical reports required by the Resolution:

- A literature review (Resolution 2a and 2b);
- A technical review of the Program and other data (Resolution 2a and 2c);
- An assessment of current legal authority (Resolution 2a); and
- A final report (Resolution 2d).

The Resolution also requires a field-ready Manual of Best Practices (Resolution 2a). The County submitted a best practices manual, and is in the process of updating it. On 28 February 2008, as required by Resolution 2e, the County of Stanislaus adopted Ordinance No. C.S. 1028 (Chapter 9.88 of Title 9, Health and Safety) to regulate food processing by-products. The County also adopted associated regulations for the use of food processing by-products in Stanislaus County for its permitted use sites.

On 4 December 2008, the Central Valley Water Board adopted Resolution No. R5-2008-0182, which is a conditional waiver of Waste Discharge Requirements for specific types of discharge (the General Waiver). A copy of the General Waiver is enclosed. Under Category 10 (*Disposal of Residual Waste to Land as a Soil Amendment*), the General Waiver allows the discharge of food-processing by-products as a soil amendment without an individual waiver or permit issued by the Central Valley Water Board if the user is enrolled under an approved County program.

The County of Stanislaus' Food Processing By-Products Use Program is hereby conditionally approved for purposes of the General Waiver with respect to the use of the material as a soil amendment, and facility operators enrolled in the County's Program are eligible for coverage under Category 10. The General Waiver does not require Category 10 facilities to submit a report of waste discharge to the Central Valley Water Board in order to obtain waiver coverage or commence discharging, provided the enrolled facilities comply with all applicable conditions of the General Waiver.

The Program's continuing status as an approved County program under the General Waiver is contingent upon the County's implementation of the Program as described, including the following:

1. The County will continue to implement the *Agreement for Monitoring and Reporting of Solid and Semi-Solid Food Processing By-Products Applied under the Stanislaus County Program* (Agreement).
2. The County will submit written notice of any new land application sites that are regulated under the County's program.
3. The County will submit written notice of any proposed changes to Ordinance No. C.S. 1028 and/or the associated regulations as required by Section A.7 of the Agreement. The County may provide this written notice before the Annual Report is due, if necessary to avoid delays in implementing proposed changes to the Program.

If information regarding the Program or a particular facility indicates that additional or different requirements are appropriate or that more information is needed, the Central Valley Water Board may modify or revoke this approval or require individual facilities to submit technical or monitoring reports. (See General Waiver, Resolved 12 and Attachment A, section 3f.)

I appreciate the County's efforts to work cooperatively with Central Valley Water Board staff and to manage food processing by-products so that they can be beneficially used in an environmentally sound manner. If you have any questions regarding this Program Approval or the General Waiver, please contact Mary Serra at (916) 464-4732 or mserra@waterboards.ca.gov.

Pamela Creedon

Pamela C. Creedon
Executive Officer

Enclosure: Resolution No. R5-2008-0182

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

RESOLUTION NO. R5-2008-0182

APPROVING
WAIVER OF REPORTS OF WASTE DISCHARGE AND
WASTE DISCHARGE REQUIREMENTS
FOR SPECIFIC TYPES OF DISCHARGE
WITHIN THE
CENTRAL VALLEY REGION

The California Regional Water Quality Control Board, Central Valley Region, (hereafter Regional Water Board) finds that:

1. California Water Code (CWC) Section 13260(a) requires that any person discharging waste or proposing to discharge waste within any region that could affect the quality of the waters of the State, other than into a community sewer system, shall file with the appropriate Regional Water Board a Report of Waste Discharge containing such information and data as may be required.

2. The Regional Water Board has a statutory obligation, pursuant to CWC Section 13263, to prescribe waste discharge requirements (WDRs) except where the Regional Water Board finds that a waiver of WDRs for a specific type of discharge is not against the public interest pursuant to CWC Section 13269.

3. CWC Sections 13260(b) and 13269 authorize the Regional Water Board to waive WDRs and Reports of Waste Discharge (RWDs), respectively, for specific types of discharge where such a waiver is not against the public interest, is conditional, and may be terminated by the Regional Water Board at any time.

4. On 1 January 2003, the CWC was amended to require that all new waivers adopted after that date for a specific discharge or type of discharge must be renewed at a minimum of every five years, and that prior to renewing any waiver the Regional Water Board shall review the terms of the waiver at a public hearing and shall determine whether the discharge should instead be subject to general or individual WDRs.

5. In January 2003, the Regional Water Board adopted Resolution No. R5-2003-0008 *Waiver of Reports of Waste Discharge and Waste Discharge Requirements for Specific Types of Discharge Within the Central Valley Region*. Resolution No. R5-2003-0008 waived WDRs, and in some cases RWDs, for 12 specific types of discharge to land. These types of discharge were found to pose little threat to water quality and required little oversight as determined by past effectiveness.

6. The Regional Water Board, in compliance with the CWC, has reviewed the previously issued waivers set forth in Resolution No. R5-2003-0008 and determined that waivers for the following types of discharges to land that pose a low threat to the quality of waters of the State should be renewed:

a. Conditional waiver of WDRs or Water Recycling Requirements (WRRs), but not the requirement to submit RWDs, for:

- Disposal of dredge material to land, and
- Water Reclamation for construction purposes and road dust control.

b. Conditional waiver of WDRs and in some instances the requirement to submit RWDs, for:

- Air conditioner, cooling, and elevated temperature waters,
- Drilling muds/Boring wastes,
- Inert solid waste disposal,
- Test pumping of fresh water wells,
- Swimming pool discharges,
- Construction dewatering discharges,
- Hydrostatic testing,
- Agricultural commodity wastes, and
- Disposal of residual waste to land as a soil amendment.

7. In 2003, the State Water Resources Control Board (State Water Board) adopted Statewide General Order No. 2003-0003-DWQ for "low-threat" discharges to land. This Statewide General Order was adopted to handle those types of discharges that posed a low threat to water quality, but was not intended to supersede the authority of the Regional Water Boards to issue individual WDRs or conditional waivers.

8. A review of the Statewide General Order shows that several categories covered by the Order are nearly identical to those covered by Resolution No. R5-2003-0008. For those categories that are also covered by the Statewide General Order, the waiver should only apply to discharges that represent the very lowest threat to water quality. As a result, categories for discharges of drilling muds/boring wastes, inert solid waste disposal, test pumping of fresh water wells, swimming pool discharges, construction dewatering discharges, and hydrostatic testing, are restricted to those instances which represent the lowest threat to water quality.

9. Waiver of WDRs for discharges from projects requiring Water Quality Certification was dropped from the General Waiver since discharges from dredge and fill activities would be best regulated under Statewide General Order No. 2003-017-DWQ for "Jurisdictional" waters and Order No. 2004-0004-DWQ for "Non-jurisdictional" waters.

10. The Regional Water Board also reviewed a previously issued waiver for discharges to land from small, short-term sand and gravel operations. This category was included in Resolution No. 82-036, which expired in 2003, but was not included in Resolution No. R5-2003-0008 since a general order for sand and gravel operations was being developed by State Water Board staff. However, that general order was never finalized or adopted. Therefore, conditional waiver of WDRs, but not the requirement to submit a RWD, should be reinstated for the small, short-term sand and gravel operations category.

11. Waiver of the requirement to file RWDs and waiver of WDRs for discharges that will cause no or insignificant impairment to water quality and that pose little risk of creating a nuisance condition are not against the public interest as they reduce the cost of activities that produce innocuous or small amounts of waste, are protective of the environment, and allow Regional Water Board staff to direct resources to address waste discharges that have significant potential to degrade water quality or create nuisance.

12. Waiver of RWDs under a discharge category does not preclude the Executive Officer from requesting a RWD for a specific project as necessary to perform an evaluation of the discharge.

13. Waiver of WDRs and in some instances RWDs for discharge categories covered under the General Waiver for low threat discharges to land, were previously waived under Resolution No. 82-036. As lead agency under the California Environmental Quality Act (Public Resources Code Section 21000, et seq.) (CEQA), the Regional Water Board determined that adoption of Resolution No. 82-036 waiving WDRs for 23 specific discharges to land would not cause a significant environmental impact and, on 23 December 1981, adopted a Negative Declaration. Pursuant to Section 15162 of the CEQA Guidelines, a subsequent environmental impact report or negative declaration is not required.

14. The conditional waiver is consistent with State Water Resources Control Board Resolution No. 68-16 (Statement of Policy with Respect to Maintaining High Quality of Waters in California) in that the waiver of WDRs imposes conditions to prevent impacts to water quality and authorizes no degradation of water quality, will not unreasonably affect beneficial uses of water, and will not result in water quality less than that prescribed in plans and policies.

15. The Regional Water Board conducted a public hearing on 4 December 2008 in Rancho Cordova, California, and considered all testimony and evidence concerning this matter.

THEREFORE BE IT RESOLVED, that in accordance with CWC Section 13269, the Regional Water Board adopts the "*Waiver of Reports of Waste Discharge and Waste Discharge Requirements for Specific Types of Discharge*" as set forth in Attachment A, hereafter informally referred to as the "General Waiver," and that;

1. The Regional Water Board waives the requirement to obtain WDRs and/or WRRs, and for some instances the requirement to submit a RWD and filing fee, for discharge types that fulfill the conditions set forth in Attachment A of this Order.

2. Discharges that result from emergency work or emergency projects as described under CWC Section 13269(c) are not affected by this action.

3. Discharge of wastes to wetlands, surface waters, drainage courses, or biologically sensitive areas, is prohibited.

4. Based on the testimony received at the aforementioned hearing, and the above-noted findings, the General Waiver is not against the public interest provided dischargers subject to such waiver:

   (a) comply with the conditions for waiver of waste discharge requirements as set forth in the General Waiver;

   (b) file with the Regional Water Board a Report of Waste Discharge and filing fee when required as part of the General Waiver; and

   (c) comply with applicable State and Regional Water Board plans and policies.

5. For those discharges requiring submittal of a RWD, the discharger must submit the fee specified in Title 23, California Code of Regulations, Section 2200, for a threat to water quality and complexity of "3C".

6. Based on the above-noted findings, it is not necessary at this time to adopt individual or general waste discharge requirements for the discharge of wastes related to the types of discharges identified in Attachment A and are conducted in accordance with the conditions specified in the General Waiver as these types of discharges are considered to be of low threat to water quality and Regional Water Board resources should focus on higher threat discharges.

7. For those categories that are also covered by Statewide General Order No. 2003-0003-DWQ for low threat discharges to land, this waiver shall only apply to those discharges that are of such good quality and of limited volume/duration that coverage under the General Order is not necessary. Specifically:

   - Non-contact cooling water discharges;
   - Drilling muds/Boring wastes;
   - Inert solid waste disposal;
   - Test pumping of fresh water wells;
   - Swimming pool discharges;
   - Construction dewatering discharges; and
   - Hydrostatic testing.

8. The discharge of any waste not specifically regulated by the General Waiver is prohibited unless the discharger complies with CWC Section 13260(a) and the Regional Water Board either issues waste discharge requirements pursuant to CWC Section 13263 or an individual waiver pursuant to CWC Section 13269, or the time frames specified in CWC Section 13264(a) have elapsed.

9. This General Waiver shall not create a vested right and all such discharges shall be considered a privilege, as provided for in CWC Section 13263.

10. Pursuant to CWC Section 13269, this action waiving the issuance of WDRs for certain specific types of discharges: (a) is conditional, (b) may be terminated at any time, (c) does not permit an illegal activity, (d) does not preclude the need for permits which may be required by other local or governmental agencies, and (e) does not preclude the Regional Water Board from administering enforcement remedies (including civil liability) pursuant to the CWC.

11. As provided by CWC Section 13350(a), any person may be civilly liable if that person is in violation of a waiver condition or WDRs, intentionally or negligently discharges waste, or causes waste to be deposited where it is discharged, into the waters of the State or creates a condition of pollution or nuisance.

12. The Executive Officer or Regional Water Board may terminate the applicability of the General Waiver described herein as to any type of discharge or individual discharger at any time when such termination is in the public interest or the activity could affect the quality or beneficial uses of the waters of the State

13. The Regional Water Board may review the General Waiver at any time and may modify or terminate the General Waiver in its entirety, as applicable for a specific type of discharge, or for individual dischargers, as is appropriate.

14. This General Waiver shall expire on 4 December 2013, unless terminated or renewed by the Regional Water Board.

I, PAMELA C. CREEDON, Executive Officer, do hereby certify the foregoing is a full, true, and correct copy of a Resolution adopted by the California Regional Water Quality Control Board, Central Valley Region, on 4 December 2008.

PAMELA C. CREEDON, Executive Officer

Order Attachments:

A. Specific Discharges Covered by the General Waiver

Staff Report

kc/DKP: 10/27/08

STAFF REPORT

RESOLUTION NO. R5-2008-0182
WAIVER OF REPORTS OF WASTE DISCHARGE AND WASTE DISCHARGE REQUIREMENTS FOR SPECIFIC TYPES OF DISCHARGE WITHIN THE CENTRAL VALLEY REGION

INTRODUCTION

Section 13263 of the California Water Code (CWC) requires that the Regional Water Board prescribe discharge requirements for discharges of waste that may affect waters of the State. The effect of some of these discharges, by virtue of waste constituent, constituent concentration, and constituent control, however, can be mitigated to have little or no effect on the quality and beneficial uses of waters of the State. Due to limited resources it is in the best interest of the public and the Regional Water Board not to expend inadequate and finite resources on regulating low-risk discharges that, when designed and operated to meet pre-set conditions, will have an insignificant potential to affect water quality or create nuisance. Section 13269 of the CWC authorizes the Regional Water Board to waive waste discharge requirements (WDRs), or to waive the requirement to submit a report of waste discharge (RWDs).

Previously, the Regional Water Board waived WDRs and RWDs for Emergency Use of Treated Wastewater as set forth in Regional Water Board Resolution No. 77-69 and for 23 types of discharges to land that posed a low-threat to water quality as set forth in Regional Water Board Resolution No. 82-036. California State Senate Bill 390 amended the CWC causing all existing waivers to expire as of 1 January 2003 and required review and renewal of any new waivers at least once every five years.

In January 2003, the Regional Water Board reviewed its waivers and adopted a Resolution for *Waiver of Waste Discharge Requirements and Reports of Waste Discharge for Specific Types of Discharge Within the Central Valley Region* (Resolution No. R5-2003-0008 or General Waiver) to replace the expired waivers (Resolution Nos. 77-69 and 82-036). Specifically, Resolution No. R5-2003-0008 waived Water Recycling Requirements (WRRs) for use of recycled water for construction and road dust control and WDRs and in some cases RWDs for 11 of the 23 discharge types covered under Resolution No. 82-036. The remaining discharge categories authorized under Resolution No. 82-036 were not renewed due to lack of demand, because they would be better handled under individual or general WDRs, or because they were covered under a separate program or general order.

Specific discharges covered under Resolution No. R5-2003-0008 were:

1. Air Conditioner, cooling and elevated temperature waters
2. Drilling Muds
3. Minor Dredging Operations
4. Inert Solid Waste Disposal
5. Test Pumping of Fresh Water Wells
6. Swimming Pool Discharges
7. Construction – Dewatering Operations
8. Construction – Hydrostatic Testing
9. Agricultural Commodity Wastes
10. Industrial Wastes Utilized for Soil Amendments
11. Water Reclamation for Construction Projects and Road Dust Control
12. Projects Requiring Water Quality Certification issued by the Regional Water Board

STATEWIDE GENERAL ORDER

In 2003 the State Water Resources Control Board adopted Statewide General Order No. 2003-0003-DWQ for low-threat discharges to land. With the expiration of all waivers on 1 January 2003, many Regions did not have a mechanism in place to regulate low-threat discharges. General Order No. 2003-0003-DWQ was adopted to cover discharges that had been previously covered under such waivers. It was not intended to supersede individual WDRs, general orders, or conditional waivers issued by the Regional Water Boards. The State Water Board did not find that categories covered by the General Order were not still appropriate for waiver.

Several of the categories covered under the Statewide General Order for low threat discharges to land are nearly identical to those included in the Resolution No. R5-2003-0008. Specifically:

- Water Well Development Discharge (Waiver Category 5);
- Monitoring Well Purge Water Discharge (Waiver Category 5);
- Boring Waste Discharge (Waiver Category 2);
- Water Main, Storage Tank, and Hydrant Flushing Discharges (Waiver Category 8);
- Pipelines and Tank Hydrostatic Testing Discharges (Waiver Category 8);
- Swimming Pool and Landscape Drainage Discharges (Waiver Category 6);
- Small Temporary Dewatering Projects (Waiver Category 7);
- Small Inert Solid Waste Disposal Operations (Waiver Category 4); and
- Small Volume Evaporative Cooling Water Discharge (Waiver Category 1).

The Statewide General Order for low threat discharges to land prohibits discharge to surface waters, discharge of hazardous or designated waste, and discharges that cause pollution. The Order specifies that discharges shall not exceed applicable Basin Plan water quality objectives, freeboard in ponds shall be at least two feet, and facilities shall be protected from erosion/flooding and also contains individual provisions specific to some of the categories, which are discussed below.

DISCUSSION

The Regional Water Board, in compliance with CWC Section 13269, reviewed the previously issued waivers set forth in Resolution No. R5-2003-0008 (which expired on 31 January 2008) to determine if the waiver for specific types of discharges that pose a low threat to the quality of waters of the State should be renewed. Based on that review, waiver of WDRs and in some cases RWDs for the following specific discharge types are proposed:

Discharge Categories:

No.	Category	Renewed
1.	Air Conditioner, cooling, and elevated temperature waters *	Yes
2.	Drilling Muds / Boring Wastes *	Yes
3.	Disposal of Dredge Material to Land	Yes
4.	Inert Solid Waste Disposal *	Yes
5.	Test Pumping of Fresh Water Wells *	Yes
6.	Swimming Pool Discharges *	Yes
7.	Construction—Dewatering Discharges	Yes
8.	Hydrostatic Testing *	Yes
9.	Agricultural Commodity Wastes	Yes
10.	Disposal of Residual Wastes to Land as a Soil Amendment (previously "Industrial" Wastes)	Yes
11.	Water Reclamation for Construction Projects and Road Dust Control	Yes
12.	Projects Requiring Water Quality Certification issued by the Regional Water Board	No
13.	Small, Short-Term Sand and Gravel Operations	Recommended to return category to the waiver.

* Categories also covered by Statewide General Order No. 2003-0003-DWQ, but for which the waiver category was retained for those discharges that represent the lowest threat to water quality.

WAIVER CATEGORIES

The following describes each type of discharge. Under the proposed conditions, none of the discharge types represent a source of significant degradation of groundwater or nuisance potential.

For those categories that are also covered by Statewide General Order No. 2003-0003-DWQ for low threat discharges to land, the waiver should only apply to those discharges that represent the very lowest threat to water quality, and in those cases, the waiver should be for both WDRs and RWDs.

1. **Air Conditioner, Cooling, And Elevated Temperature Waters:** Wastewater generated from air conditioning, cooling, ice making, or refrigeration systems are collectively referred to as cooling water, which includes contact and non-contact cooling waters. Non-contact cooling water refers to cooling water which does not come in contact with any raw material,

intermediate product, waste product, or finished product. Additives, such as metal-containing algacides, are often used in both contact and non-contact cooling water to control algae growth.

For contact cooling water discharges, the waiver of WDRs (but not RWDs) should be continued, provided that:

- Waste constituent concentrations must be comparable to uppermost underlying groundwater (e.g., EC less than or equal to 500 umhos/cm over source water);
- BOD must be consistently less than 30 mg/L without treatment and, if impounded, less than 10 lb/acre/day; and
- If additives are used, provide Material Safety Data Sheets (MSDS) and include an analysis for metals in the RWD, especially if metal-containing algacides are used.

Non-contact cooling water discharges are covered under Statewide General Order 2003-0003-DWQ for low threat discharges to land, but it does not contain any specific requirements for this category. The waiver of WDRs for non-contact cooling water should be renewed for discharges provided that:

- Waste constituent concentrations must be comparable to uppermost underlying groundwater (e.g., EC less than or equal to 500 umhos/cm over source water); and
- If additives are used, provide MSDS and include an analysis for metals in the RWD, especially is metal-containing algacides are used.

The need for a RWD should be waived for non-cooling water discharges that are of such good quality (e.g., no additives including metal-containing algacides) and of limited volume/duration (e.g., one time or limited seasonal discharges).

2. **Drilling Muds/Boring Wastes**: Drilling muds and boring wastes are generated during drilling as part of a subsurface investigation or well drilling operation and consist of formation sediment, water, and drilling muds. Drilling muds typically consist of bentonite clay or formation fines mixed with water or a non-toxic mineral oil. A variety of additives may be added to the drill mud to handle specific situations encountered during the drilling process. The liquefied soil and rock cuttings from the borings, along with any bentonite, are commonly contained in a portable tank or excavated sump during drilling.

   Drilling activities are generally regulated by local agencies such as cities or counties and do not require oversight by the Regional Water Board. Borings associated with oil and gas wells typically pose the highest potential threat to water quality. However, the Department of Oil, Gas, and Geothermal Resources conducts routine inspections of all oil and gas fields as part of its duties and is in regular contact with Regional Water Board staff regarding observed violations or illegal dumping. The Regional Water Board may need to monitor how local agencies oversee drilling activities.

The disposal of drilling muds/boring waste to land is covered under Statewide General Order No. 2003-0003-DWQ for low threat discharges to land.

Due to oversight of drilling operations by local agencies, the waiver of WDRs and RWDs for disposal of drilling muds/boring wastes should be renewed, except in those instances where it is determined that the local oversight will be insufficient to protect water quality, provided that:

- The drilling operations are conducted in uncontaminated soils;
- The discharge is considered "non-hazardous" and does not contain halogenated solvents;
- Buried drilling muds must first be dried then the site restored to pre-sump conditions and covered with at least one foot of clean soil; and
- The bottom of the sump must be at least 5 feet above highest groundwater elevation and at least 100 feet from the nearest surface water.

Drilling operations that require greater oversight than that provided by local agencies should be regulated under the General Order or an individual waiver or WDRs.

3. **Disposal of Dredge Material to Land (formerly Minor Dredge Operations)**: This category covers discharge of dredge material to land from small scale dredging projects such as bridge replacement and construction projects where pilings and abutments must be placed in a stream channel or to restore or increase storage capacity in water storage reservoirs. Minor dredging operations are generally of short duration and disposal of dredge material to land in a controlled manner poses little threat to groundwater quality if essentially free of contaminants that have a potential to cause groundwater degradation. As a condition of this waiver, the dredged material must be nontoxic and discharged to land where it will not erode or deposit sediment into any surface waters or storm drains.

   This waiver category covers only the **disposal of dredge material to land**, and is not associated with the dredging operation itself. In-stream dredging operations are covered by federal regulations under a 404 permit for Waters of the U.S. or by Statewide General Order No. 2004-0004-DWQ for non-Jurisdictional Waters.

   The previous waiver (R5-2003-0008) limited the waiver to small-scale (minor) dredging projects involving 1,000 cubic yards or less. However, the original waiver (82-036) did not specify a limit on what would constitute a minor dredging operation. Since this category is for the disposal of material and not the dredging operation, the term "minor" should be interpreted in the context of the disposal, not the dredging. Long-term or major dredging projects involving large volumes of dredge material need to be regulated under an individual waiver or WDRs. The disposal of dredge material under this waiver should be conditional upon the use of best management practices (BMPs) to prevent erosion or runoff conditions from the emplaced sediments, and prohibit the disposal of dredge material in wetland areas or surface water drainage courses. Larger projects or projects with contaminants that have a greater potential to cause groundwater degradation or which might affect surface waters or wetland areas are best regulated under general or individual WDRs.

The waiver of WDRs (but not RWDs) for disposal of dredge material to land from minor dredging operations should be continued, provided that:

- If the dredged material may contain constituents that are potentially hazardous or at concentrations that could impair beneficial uses of receiving water, the discharger must provide a chemical analysis of the fine (silt and clay) portion of the substrate material and a written waste management plan (WMP) describing BMPs which will be employed to prevent excess erosion and prevent runoff from the emplaced sediments; and
- Excludes: disposal of dredge material from mining operations.

4. **Inert Solid Waste Disposal:** "Inert wastes" is defined in Title 27 Section 20230(a) as "that subset of solid waste that does not contain hazardous waste or soluble pollutants at concentrations in excess of applicable water quality objectives, and does not contain significant quantities of decomposable waste".

   The disposal of "Inert Solid Wastes" is covered under Statewide General Order No. 2003-0003-DWQ for low threat discharges to land. Specific requirements include: (1) limited to operations covering two acres of land or less, (2) does not contain hazardous waste or soluble pollutants at concentrations in excess of water quality objectives or contain significant quantities of decomposable waste. The requirements include a list of acceptable inert wastes, other potential inert wastes not included on the list must be approved by the Regional Water Board prior to disposal.

   With the existence of General Order No. 2003-0003-DWQ, the waiver of WDRs and RWDs for Inert Solid Waste disposal should be renewed only for a short-term one-time disposal. Inert Solid Waste disposal operations of more then a few month's duration should be regulated under the General Order or an individual waiver or WDRs.

5. **Test Pumping Of Fresh Water Wells:** Many public and private well owners need to periodically discharge potable or relatively contaminant-free water generated when a well is developed or maintained, or from the periodic discharge of purge water from monitoring wells in instances where there is no threat to water quality or nuisance. Water quality parameters of concern for this type of discharge are generally suspended material, turbidity, and chlorine, which are primarily a concern to surface water. High volume discharges have the potential to impact adjacent property owners or surface water and BMPs such as berms or setbacks should be employed to prevent excessive erosion or runoff conditions. Discharge of water to land from development and testing of fresh water wells, including monitoring wells, is covered under the Statewide General Order No. 2003-0003-DWQ for low threat discharges to land, which specifies that the discharge shall remain onsite and not be discharged in a manner such as to cause ponding or threaten discharge to surface waters.

The waiver of WDRs and RWDs for those discharges generated from a single one time discharge during testing or development of an individual domestic or irrigation supply well, or purge water from routine sampling of monitoring wells as part of a compliance monitoring program should continue, provided that:

- The discharge remains on the designated property, unless there is a signed use agreement; and
- The discharge shall not be conducted in a manner such as to cause nuisance conditions or threaten surface waters; and
- Excludes discharge from wells associated with a cleanup or remediation project unless conducted under an approved cleanup or remediation management plan.

6. **Swimming Pool Discharges**: Pool water discharges are infrequent, low to high volume discharges that are relatively free of waste constituents. In urban areas, disposal of pool water is regulated by municipalities, which typically have engineered stormwater systems that may require a pool drainage permit before discharge. Areas that do not have engineered stormwater systems depend on land discharge. Direct flow of pool water onto land provides some treatment before it enters into groundwater and is preferred over surface water discharges.

   Swimming pool discharges are covered under Statewide General Order No. 2003-0003-DWQ for low threat discharges to land, but it does not contain any specific requirements for this category. The waiver of WDRs and RWDs for these discharges should be renewed for those discharges involving a single individual pool at infrequent intervals (e.g., once every three years).

7. **Construction - Dewatering Discharges**: This is a sub-type of an existing waiver for construction, which is conditional upon the use of BMPs. Dewatering discharges include extracted groundwater and water collected from cofferdams or diversions. Discharges to land, instead of to surface water, are typically one-time, non-stormwater discharges of short duration. Discharge may be to a terminal basin or used for irrigation or dust control. These discharges may be onsite or to land in the same proximity with appropriate agreement from the property owner.

   Construction dewatering discharges are covered under Statewide General Order No. 2003-0003-DWQ for low threat discharges to land. This Order excludes dewatering operations in areas with unstable geologic units or expansive soils or in areas where it might conflict with existing agricultural use or Williamson Act contracts.

   With the existence of General Order No. 2003-0003-DWQ, which includes low threat discharges to land from construction dewatering operations, the waiver of WDRs and RWDs for construction- dewatering discharges should be renewed only for those discharges of limited duration of no more than a few weeks. Discharges of more than a few weeks, or requiring treatment, should be regulated under a General Order or an individual waiver or WDRs.

8. **Hydrostatic Testing:** This category covers discharge to land of hydrostatic test water. Hydrostatic testing is generally a one-time activity used to demonstrate the integrity of pipelines and pressure vessels. Source waters for hydrostatic tests are local and, except for waste constituents picked up from the structure being tested, have like or better quality than underlying groundwater. The spent hydrostatic test waters may discharge to an impoundment for infiltration, or used for irrigation, or dust control.

   Discharges of hydrostatic test water to land from new and potable water pipelines pose very little threat to groundwater quality from soluble constituents. Pipelines and tanks that have previously contained crude or refined oil and gas present a different situation. If hydrostatic testing waters are suspect, pre-discharge analytical testing must be performed.

   Discharges to land from hydrostatic testing waters are covered under Statewide General Order No. 2003-0003-DWQ for low threat discharges to land. This Order does not contain any specific requirements for this category, except it excludes water used to test tanks or pipelines that have been used to store or convey any medium other than potable water unless the Discharger has demonstrated to the Regional Water Board that all residual pollutant concentrations have been reduced to levels below water quality objectives.

   With the existence of General Order No. 2003-0003-DWQ, which includes low threat discharges to land from hydrostatic testing, the waiver of WDRs for discharges of hydrostatic testing waters should be renewed only for those discharges of limited duration of no more than a few weeks, provided the discharger has demonstrated to the Regional Water Board that all residual pollutants have been removed or are below water quality objectives. Discharges of more than a few weeks, or requiring treatment, should be regulated under a General Order or an individual waiver or WDRs.

   The need to submit a RWD should be waived for those discharges from lines or tanks that are of such good quality (i.e., have contained potable water only) that they pose no threat to waters of the State.

9. **Agricultural Commodity Wastes:** This category covers discharge to land of commodity wastes for agricultural use. This waiver allows for the expedient discharge of unsalvageable commodities to land under atypical situations. The primary threat occurs from possible nuisance conditions as a result of decomposition. The typical mitigation is to spread the waste over a reasonable area and plow it under as it begins to generate odors from decomposition. Sites may require berms, setbacks, and/or other measures to prevent discharge to surface water.

   Because the Central Valley is one of the world's largest food producing regions, numerous scenarios can generate commodity waste. A typical commodity becomes a waste as a result of culling, spoilage, or contamination. Processed food and processed food residuals are not included in this type of waste (e.g., whey). This waiver does not extend to dead animals or animal byproducts (i.e., flesh, organs, unprocessed hide, blood, bone, and marrow).

The California Code of Regulations (CCR), Title 3 (Food and Agriculture), Division 6 (Pesticide and Pest Control Program), section 6000 defines an "agricultural commodity" as an unprocessed product of farms, ranches, nurseries and forests (excepting livestock, poultry, and fish), that includes: fruits, vegetables, grains, legumes, animal feed and forage crops, wood, fiber, and oil crops (i.e., safflower, sunflower, corn, and cottonseed).

Generally, commodity wastes are produced as part of the seasonal wasting of culls or from a specific incident, such as the improper application of pesticide, making a field product no longer suitable for human consumption. Other instances associated with a commodity becoming a waste include transportation accidents, loss of refrigeration, or any of a variety of conditions resulting in spoilage. In most cases, when reasonably fresh and uncontaminated, the commodity waste may be used as cattle or swine feed.

Waiver of WDRs and RWDs for a limited (one-time) discharge, and WDRs (but not RWDs) for a continuous or recurring discharge, to land of agricultural commodity wastes should be continued, provided that:

- BMPs are employed to preclude the potential for nuisance conditions;
- Wastes must not be discharged in proximity to buildings occupied by people; and
- Excludes: discharge of processed food or processed food residuals (e.g., whey), dead animals, or animal byproducts.

10. **Disposal of Residual Waste to Land as a Soil Amendment:** This category covers discharge to land of residual wastes, previously referred to as "Industrial Wastes" for use as a soil amendment. A soil amendment is any material added to the soil to improve its physical properties, such as water retention, permeability, infiltration, pH, or to add nutrient or organic matter for plant growth. The benefit of a soil amendment is dependent on soil type, climate, and crop type. This category would not include the use of biosolids from municipal treatment plants as a soil amendment as this is generally covered under Statewide General Order No. 2004-0012-DWQ.

    Residual wastes (i.e., manure, bone meal, used diatomaceous earth, dried stillage leathers from wineries, etc.) contain constituents, which when applied correctly will improve soil conditions and add needed nutrients and organic material. However, these materials can also contain additional waste constituents such as salts that can impact groundwater quality and affect beneficial uses.

    Some counties (e.g., Stanislaus County) are in the process of developing their own programs, including establishment of a county ordinance to handle the discharge of solid or semi-solid food processing residuals to land. At this time only Stanislaus County is working with the Regional Water Board to prepare and implement a countywide program for the disposal of food processing residuals to land as a soil amendment. The Regional Water Board encourages the regulation of these types of discharges by individual counties as this conserves staff resources and provides for better local oversight.

Waiver of WDRs and RWDs for the disposal of residual wastes to land as a soil amendment should be continued, provided that:

- The discharge is enrolled under an approved County Program.

Discharges in counties without an approved program or which do not qualify for coverage under a county program, should be regulated under an individual waiver or WDRs.

11. **Water Recycling For Construction Projects And Road Dust Control:** During the late 1970s, necessity drove the increased use of reclaimed water. Unlike other types of reclamation (e.g., green belt water, power plant feed water, etc.), use of reclaimed water for construction activities and road dust suppression are typically of limited duration.

    Title 22 contains criteria for a number of uses of reclaimed water, including construction and dust suppression (i.e., Section 60307(b) states that disinfected secondary-23 recycled water (as defined by section 60301.225) may be used for backfill consolidation around non-potable piping, soil compaction, concrete mixing, and dust control on roads and streets). In addition, the reclaimed water typically must be trucked to a construction site or stretch of unpaved road and the amounts used are restricted to that necessary to accomplish sound construction or minimize dust while maximizing coverage, so runoff and infiltration are unlikely. Waiver of water recycling requirements (WRRs) for construction projects and road dust suppression facilitates the reuse of reclaimed water by expediting the process. Restricting use to wastewater that has been treated to Title 22 standards and adherence to Title 22 use restrictions will protect public health.

    Waiver of WRRs (but not a Report of Water Recycling or Title 22 Engineering Report) for use of recycled water for construction projects and road dust control should be continued, provided that:

    - Reclaimed water must be treated to Title 22 standards by permitted recycled water producer; and
    - User must certify that the discharge will conform with Title 22 restrictions and Department of Public Health (DPH) Guidelines and that the use has been approved by local and State health departments.

12. **Projects Requiring Water Quality Certification:** Water Quality Certification is intended to protect surface waters (e.g., rivers, streams, lakes, and wetlands, including vernal pools) by ensuring that dredge or fill activities will not cause these waters to exceed State water

quality standards. As a result, this category is not directly associated with a discharge of waste to land and does not fit with the other categories included in this waiver.

By federal law, any dredge and fill activity that results in a discharge to a water of the U.S. (jurisdictional waters) requires a federal permit under section 404 of the Clean Water Act (CWA). Pursuant to Section 401 of the CWA, the federal permit must include a certification by the Regional Water Board that the dredge or fill activity will comply with State water quality standards. In 2001, the U.S. Supreme Court issued a decision that certain waters are not subject to the CWA (isolated waters). Following this ruling, most projects involving isolated waters no longer require a 404 permit. However, those isolated waters are still considered waters of the State. In either case, the California Water Code requires that the activity be regulated by WDRs or a waiver.

The original waiver (82-036) was for "projects where application for Water Quality Certification is required." The limitation on the waiver was "where project (normally minor construction) is not expected to have a significant water quality effect and project complies with Fish and Game agreements." The previous waiver (R5-2003-0008) continued that category. Since then, the State Water Board adopted Statewide General Order No. 2003-0017-DWQ for dredge and fill activities associated with jurisdictional waters and Statewide General Order No. 2004-0004-DWQ for dredge and fill activities associated with isolated waters. The General Order for jurisdictional waters does not specify a limit on the size of the dredge or fill activity. The General Order for isolated waters is restricted to discharges of not more than two-tenths of an acre and 400 linear feet, or not more than 50 cubic yards. The procedure to process Water Quality Certifications for dredge and fill activities is essentially identical for both the General Orders and the waiver. In both cases the permit fee and application are submitted and processed as a Water Quality Certification, and the project enrolled under either the General Order or the waiver.

This category should not be renewed as dredge and fill activities are now covered under Statewide General Orders. Projects that exceed the restrictions in the General Order for isolated waters would not be consistent with the limitations in the original waiver. Those projects would need to have individual waste discharge requirements or an individual waiver adopted for the in-stream dredge and fill activity. Disposal of dredged material on land would continue to be waived under Category 3.

13. **Small, Short-Term Sand and Gravel Operations**: Sand and gravel operations provide aggregates for construction projects. Water is used in the process to control dust, which can result in increases in silt and sediment that is eventually discharged to land or into a holding pond. This category was included in the original General Waiver (Resolution No. 82-036) but it was not included in Resolution No. R5-2003-0008 since a general order for sand and gravel operations was to be developed. However, that general order was never finalized or adopted.

    Minor sand and gravel operations are generally of short duration (e.g., less than one year). Water quality parameters of concern for this type of discharge are generally suspended material and turbidity, which are primarily a concern to surface waters. Such water, discharged to land poses almost no threat to groundwater because suspended material and turbidity are effectively filtered out as the water percolates through the vadose zone, and is normally of better quality than the shallow zone of underlying groundwater. The discharge should be conditional upon use of BMPs to prevent erosion or runoff conditions.

While this category was not included in Resolution R5-2003-0008, it was included in the Negative Declaration adopted for the original waiver (Resolution No. 82-036).

Waiver of WDRs (but not RWDs) for discharge to land from small, short-term, sand and gravel operations should be included in the General Waiver, provided that:

- BMPs are employed to prevent excessive erosion or runoff conditions;
- The impoundment or use area poses low risk of nuisance;
- All wash waters are confined to land; and
- Excludes sand and gravel operations in stream channels or drainage courses that have the potential to discharge to surface waters.

NOT COVERED BY THE PROPOSED WAIVER

There were several types of discharge included in the original General Waiver (Resolution No. 82-036) that were not included under Resolution No. R5-2003-0008 and were not considered for renewal due to lack of demand, because they would be better handled under individual or general WDRs, a separate waiver, or because they are covered under a separate program (i.e., NPDES program). These, include:

- Clean oil containing no toxic materials;
- Stormwater runoff;
- Erosion from development;
- Pesticide rinse waters from applicators;
- Confined animal waste facilities;
- Minor stream channel alterations and suction dredging;
- Small metal mining operations;
- Food processing wastes spread to land
- Timber harvesting
- Minor hydro projects
- Irrigation return water; and
- Septic tank/leachfield systems.

REPORTING REQUIREMENTS

The waiver requires submittal of reports as directed by the Executive Officer. The reports would represent the minimum reporting threshold to monitor compliance with waiver conditions and provide data necessary for consideration of renewal of the General Waiver.

BEST MANAGEMENT PRACTICES

A condition of waiver for several types of discharge is implementation of BMPs. The set of possible BMPs for each specific type of discharge is large. In addition, BMPs are typically site-specific and can change with time as new standards and information from industry-specific studies and practices become available. In the context of this waiver, BMPs refer to the set of methods, measures, and practices employed by a particular industry practicable at the site to limit potential impacts to water quality. Examples include schedules of activities, prohibited practices, maintenance procedures, and other management practices.

CEQA

On 23 December 1981, the Regional Water Board adopted a Negative Declaration for the waiver of WDRs for 23 categories of discharges. The Negative Declaration determined that the waiver of WDRs for these discharges would not cause a significant environmental impact. There have been no significant changes in the discharges to be covered in the proposed renewal of the General Waiver, so the Negative Declaration will still apply.

ANTIDEGRADATION / RESOLUTION NO. 68-16

The discharges proposed for coverage under the General Waiver renewal are those that represent the "lowest threat" to water quality or nuisance. By virtue of waste constituent, constituent concentration, constituent control, and the conditions prescribed in the waiver the specific discharge types proposed for renewal under the General Waiver can be effectively mitigated to have little or no affect on the quality and beneficial uses of waters of the State and would, therefore, be consistent with the antidegradation policy.

kc/DKP: 10/27/08

RESOLUTION NO. R5-2008-0182

ATTACHMENT A
CONDITIONS OF DISCHARGE FOR
WAIVER OF REPORTS OF WASTE DISCHARGE AND
WASTE DISCHARGE REQUIREMENTS
FOR SPECIFIC TYPES OF DISCHARGE

Each person who discharges a waste type identified herein that is of very low complexity and very low threat to water quality and who meets the conditions specified herein for that type of discharge need not obtain waste discharge requirements and may commence discharge forthwith of that waste type, provided:

1. The Discharger first submits, if requested by the Executive Officer or if specified below for the discharge type or situation, a filing fee and Report of Waste Discharge (RWDs) that documents that the discharge will comply with the conditions of waiver, and obtains written approval of waiver from the Executive Officer.

2. For discharge types covered by Statewide General Order No. 2003-0003-DWQ for low threat discharges to land, the Discharger must provide information that demonstrates that the discharge is of such low-threat/duration that waiver of WDRs and RWDs is appropriate. Specifically: (a) evaporative cooling water discharges; (b) drilling muds/boring waste discharges; (c) inert solid waste disposal; (d) test pumping of fresh water wells; (e) swimming pool discharges; (f) construction dewatering discharges; and (g) hydrostatic testing.

3. The Discharger complies with the conditions in this document specific to the type of discharge and with the following general provisions:
   a. The discharge shall neither create nor threaten to create a condition of nuisance, as defined by CWC Section 13050.
   b. The discharge shall neither degrade the quality of waters of the State nor create or threaten to create a condition of pollution or contamination as defined by CWC Section 13050.
   c. The discharge shall not contain waste constituents in hazardous concentrations, as defined by Title 22, California Code of Regulations (CCR), Division 4.5, Article 11.
   d. The discharge of any waste not specifically regulated by this waiver is prohibited unless the discharger obtains waste discharge requirements or other permission from the Regional Water Board for that waste.
   e. The discharger shall allow Regional Water Board staff reasonable access onto the affected property for the purpose of performing inspections to determine compliance with waiver conditions.
   f. The discharger shall submit technical and monitoring reports as specified by the Executive Officer and consistent with CWC Section 13267.
   g. Discharge of waste to wetlands, surface waters, drainage courses, or biologically sensitive areas is prohibited.
   h. The discharger shall comply with all federal, state, county, and local laws and regulations pertaining to the discharge.
   i. It shall not be a defense for a discharger in an enforcement action that it would have been necessary to halt or reduce its activity in order to maintain compliance with conditions of waiver.

j. This waiver expires on 4 December 2013. A discharger of waste subject to a RWD shall submit a new RWD and filing fee before then for consideration of renewal of the waiver, or cease discharge.

Type of Waste Discharge	RWD and Filing Fee Required [1]	Conditions
1. Air conditioner, cooling and elevated temperature waters discharged to land	**Contact Cooling Water-Yes**	• Waste constituent concentrations comparable to underlying groundwater (e.g., EC less than 500 umhos/cm over source water). • Biochemical oxygen demand (BOD) must be consistently less than 30 mg/L without treatment and, if impounded, must be less than 10 lb/acre/day. • If additives are used, provide the appropriate MSDS and include an analysis for metals in the RWD, especially if metal-containing algacides are used.
	Non-Contact Cooling Water-Yes	• Waste constituent concentrations comparable to underlying groundwater (e.g., EC less than 500 umhos/cm over source water). • If additives are used, provide the appropriate MSDS and include an analysis for metals in the RWD, especially if metal-containing algacides are used.
	Non-Contact Cooling Water-No [2]	• Waste constituent concentrations comparable to underlying groundwater (e.g., EC less than 500 umhos/cm over source water). • Discharge is of good quality (e.g., no additives, including metal-containing algacides). • One time or limited seasonal discharge.

Type of Waste Discharge	RWD and Filing Fee Required [1]	Conditions
2. Drilling muds/Boring wastes [3]	No[2]	• Drilling operations in uncontaminated soils • Drilling mud must be considered non-hazardous and contain no halogenated solvents. • Buried drilling muds must first be dried and the site restored to pre-sump conditions and covered with at least one foot of clean soil. • Sump must be greater than 100 feet from nearest surface water and bottom of the sump must be at least 5 feet above highest groundwater.
3. Disposal of dredge material to land	Yes	• If the dredged material may contain constituents that are potentially hazardous or at concentrations that could impair beneficial uses of receiving water, the discharger must provide a chemical analysis of the fine (silt and clay) portion of the substrate material and a written waste management plan (WMP) describing BMPs which will be employed to prevent excess erosion and prevent runoff from the emplaced sediments. • Excludes disposal of dredge material from mining operations.
4. Inert solid waste disposal [3]	No[2]	• Short-term or one time disposal of no more than a few months. • Wastes must be insoluble, without decomposable solids, and contain no "free liquids". • The site must be well constructed, managed to restrict access, and outside of natural or man made drainage courses. • Excludes tires, semi-solid wastes, dewatered sludge, liquid wastes, ash, fresh concrete solids, and any waste deemed by the Executive Officer to have the potential to degrade groundwater, even if classified as inert by Title 27.

Type of Waste Discharge	RWD and Filing Fee Required [1]	Conditions
5. Test pumping of fresh water wells [3]	No[2]	• One time discharge from testing or development of individual domestic or irrigation supply well or periodic discharge of purge water from a monitoring well as part of compliance monitoring program. • Discharge limited to on-site property, unless there is a signed use agreement. • Discharge shall not be conducted in a manner such as to cause nuisance conditions or threaten surface waters. • Excludes discharge from wells associated with a cleanup or remediation project unless conducted under an approved cleanup or remediation management plan.
6. Swimming pool discharges [3]	No[2]	• Infrequent (e.g., once every three years) • Single pool
7. Construction – dewatering discharges [3]	No[2]	• Limited volume and duration of no more than a few weeks. • The impoundment or use area must pose low risk of nuisance and the water must infiltrate/evaporate within 72 hours.
8. Hydrostatic testing [3]	Yes	• Limited volume and duration of no more than a few weeks. • Provide data to demonstrate that all residual pollutants have been removed or are below water quality objectives. • The impoundment or use area must pose low risk of nuisance and the water must infiltrate/evaporate within 72 hours.
	No[2]	• Testing on existing lines or tanks used for potable water only or new lines or tanks that have only ever contained potable water.

Type of Waste Discharge	RWD and Filing Fee Required [1]	Conditions
9. Agricultural commodity wastes	**Recurring Discharge-Yes** **One-time Discharge-No[2]**	• An "agricultural commodity waste" is an unprocessed product excepting livestock, poultry, and fish that becomes a waste as a result of culling, spoilage, or contamination. • BMPs are employed to preclude the potential for nuisance conditions. • Wastes must not be discharged in close proximity to buildings occupied by people. • Excludes discharge of processed food or processed food residuals (e.g., whey), dead animals, or animal byproducts.
10. Disposal of residual waste to land as a soil amendment (previously - Industrial wastes utilized for soil amendments)	**No[2]**	• The discharge is enrolled under an approved County Program.
11. Water reclamation for construction projects and road dust control	**Yes**	• Reclaimed water must be treated to CCR Title 22 standards by permitted recycled water producer. • User must certify that the discharge will conform with Title 22 restrictions and Department of Public Health Guidelines and that the use has been approved by local and State health departments.
12. Projects Requiring Water Quality Certification issued by the Regional Water Board		• Not renewed

Type of Waste Discharge	RWD and Filing Fee Required [1]	Conditions
13. Small, Short-Term Sand and Gravel Operations	Yes	• BMPs are employed to prevent excessive erosion or runoff conditions. • Impoundment or use area must pose low risk of nuisance. • All wash waters are confined to land. • Excludes sand and gravel operations in stream channels or drainage courses that have the potential to discharge to surface waters.

1 Does not preclude the Executive Officer from requesting a RWD for a specific project as necessary to perform an evaluation of the discharge.
2 Applicant should contact staff regarding applicability of the discharge meeting the conditions of the waiver without need for a RWD.
3 Covered by Statewide General Order No. 2003-0003-DWQ for low threat discharges to land. For those categories that are covered by both, the waiver should only apply to those discharges that represent the very lowest threat to water quality.

kc/DKP: 10/27/08

MEMO

Date: June 30, 2009

To: Sonya Harrigfeld, Director
Dept. of Environmental Resources, Stanislaus County

From: Dr. Horacio Ferriz, Department of Physics and Geology
California State University, Stanislaus

CC: Joe Bezerra, CATI Director of Operations,
California State University, Fresno
Dr. Sajeemas (Mint) Pasakdee, Soil Scientist/Agronomist
California Agricultural Technology Institute (CATI),
California State University, Fresno
Nat Dellavalle, CPAg/SS, Principal, Dellavalle Laboratory Inc.
Martin Reyes, Stanislaus County Food Processing By-Products
Re-Use Committee
William J. Lyons, Jr., Mapes Ranches & Lyons' Investments
James Mortensen, Superintendent, Del Monte Foods-Plant No. 1

Subject: Fluid Infiltration in Soils Used For Land Application of Food-Processing Vegetable Byproducts

Thank you for the continuing confidence of Stanislaus County in the work of the Research Team to fully address the matters raised by the Central Valley Regional Water Quality Control Board (CVRWQCB).

Attached please find the report of the Phase 1 investigation "Fluid Infiltration in Soils Used For Land Application of Food-Processing Vegetable Byproducts". Food-processing byproducts, such as culled produce, pits, stems and skins, can be "recycled" into agricultural operations by applying them to soils. To minimize environmental impact, however, good management practices have to be identified, particularly with regard to chemical transport by infiltration of irrigation water and interstitial byproduct fluid.

As you know, the research team developed "Recommendations for Further Studies" in its *Technical Review of the Stanislaus County Program*, submitted to the CVRWQCB in April 2007. Among these recommendations, we proposed a research plan to quantify the movement of fluid through soils that might be used for land-application of vegetable byproducts. The ultimate purpose of this research task is to present recommendations to minimize the environmental impact of land application of vegetable food-processing byproducts.

ATTACHMENT B

Double-ring infiltrometer measurements in sand, silty sand, and clay show that sandy soils and dry, cracked clay soils have irrigation water infiltration rates of 0.08 to 0.26 cm/min, whereas silty soils have irrigation water infiltration rates of less than 0.05 cm/min. Infiltration rates measured using a tomato paste slurry are significantly lower, regardless of the nature of the soil (0.01 cm/min or less), probably because the suspended solids promptly plug soil porosity. Similar measurements made on aged, cracked asphalt underlain by silty soils yielded infiltration rates of 0.2 to 0.5 cm/min for clear water, and 0.01 to 0.03 cm/min for the interstitial fluid of the tomato paste slurry.

To measure in-situ propagation of infiltration fronts we installed two different stacks of moisture sensors in agricultural sites with fine sand with silt (sandy loam), and silty clay, respectively. Each stack consisted of five Decagon soil moisture sensors (Model EC-20), buried horizontally at progressively deeper depths (2 to 30 inches) within the soil profile. For the sandy loam site, moisture fronts due to irrigation propagated rapidly to 5-inch and 10-inch depths at a rate of about 9 in/hour. Propagation was slower at deeper levels (e.g., 3 in/hour between the 10 and 20" depth intervals), and very few fronts propagated to the 30 inch depth.

The data from the silty clay site were quite different. Moisture fronts propagated quickly through the upper 30 inches of this soil profile, at a rate of 30 in/hour. These high values are consistent with the results we obtained from the infiltration experiments in dry, cracked clay. The explanation is probably the same: As the clayey soils are ripped and disced they break into small peds with size ranges from 1 to 10 mm. From that point onward the soils behave more as sandy gravels than clays.

Taking in consideration the results from the infiltration experiments and the soil moisture probes, we recommend adoption of the following best management practices:

- Water does move through the soil profile, down to depths of 30 inches and beyond. The greater infiltration rates seem to occur in clean, well-sorted sands with little fines, and in dry and cracked clayey soils. Without amendment (e.g., a few months of moisture conditioning), these soils should be avoided for land-application. Soils with clear-water infiltration rates of 0.05 cm/min or more should be avoided when using flood irrigation. Alternative irrigation methods (e.g., sprinkler irrigation) would need to be assessed for these soils, by installing soil moisture sensors in a test plot and confirming that managed irrigation does indeed limit water propagation through the soil profile.

- Silty sands and sandy loam soils seem to have the lowest infiltration rates, and are recommended for land application. These granular soils are unlikely to crack and easily anneal if cracked or burrowed. Infiltration rates of 0.01 to 0.05 cm/min seem to offer a good compromise between reduced infiltration and good soil moisture release to plants.

- Measurement of infiltration rate with the procedure and equipment used in this study is a simple and inexpensive way to "rate" the suitability of a soil for land application of vegetable food-processing byproducts.

- Even silty sands will experience propagation of water down to the 30-inch depth if rainfall or irrigation exceeds rates of 1 inch/day. Chemical transport by these "break-through" events needs to be taken into account when evaluating potential impacts to groundwater. Measurement of soil moisture by sensors like the ones used in this study is a simple and inexpensive way to keep track of the behavior of water movement in any given type of soil.

- Temporary storage of thick "cakes" of vegetable slurries is not likely to cause undue amounts of infiltration, because the vegetable particles tend to seal the pores. Best performance can be expected from storage over silty sands and sandy loam soils, or over asphalt laid over silty sand soils. Storage over jointed concrete surfaces is not recommended, as the concrete slabs may "hide" cavities formed by burrowing animals.

Attachments: Report, 21 pages
Figures, 31 figures
Appendix 1. Chemical analyses of vegetable and fruit slurry samples
Appendix 2. Grain-size analyses and physical and chemical properties of soils as reported in the NRCS Web Soil Survey
Appendix 3. Infiltration data in soils
Appendix 4. Moisture and electric conductivity measurements
Appendix 5. Infiltration data on asphalt and concrete

FLUID INFILTRATION IN SOILS USED FOR LAND APPLICATION OF FOOD-PROCESSING VEGETABLE BYPRODUCTS

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ABSTRACT

Food-processing byproducts, such as culled produce, pits, stems and skins, can be "recycled" into agricultural operations by applying them to soils. To minimize environmental impact, however, good management practices have to be identified, particularly with regard to chemical transport by infiltration of irrigation water and interstitial byproduct fluid ("juice"). Double-ring infiltrometer measurements in sand, silty sand, and clay show that sandy soils and dry, cracked clay soils have irrigation water infiltration rates of 0.08 to 0.26 cm/min, whereas silty soils have irrigation water infiltration rates of less than 0.05 cm/min. Infiltration rates measured using a tomato paste slurry are significantly lower, regardless of the nature of the soil (0.01 cm/min or less), probably because the suspended solids promptly plug soil porosity. Similar measurements made on aged, cracked asphalt underlain by silty soils yielded infiltration rates of 0.2 to 0.5 cm/min for clear water, and 0.01 to 0.03 cm/min for the interstitial fluid of the tomato paste slurry.

To measure in-situ propagation of infiltration fronts we installed two different stacks of moisture sensors in agricultural sites with fine sand with silt (sandy loam), and silty clay, respectively. Each stack consisted of five Decagon soil moisture sensors (Model EC-20), buried horizontally at progressively deeper depths (2 to 30 inches) within the soil profile. For the sandy loam site, moisture fronts due to irrigation propagated rapidly to 5-inch and 10-inch depths at a rate of about 9 in/hour. Propagation was slower at deeper levels (e.g., 3 in/hour between the 10 and 20" depth intervals), and very few fronts propagated to the 30 inch depth.

The data from the silty clay site were quite different. Moisture fronts propagated quickly through the upper 30 inches of this soil profile, at a rate of 30 in/hour. These high values are consistent with the results we obtained from the infiltration experiments in dry, cracked clay. The explanation is probably the same: As the clayey soils are ripped and disced they break into small peds with size ranges from 1 to 10 mm. From that point onward the soils behave more as sandy gravels than clays.

Analysis of the infiltration data leads to the following best management practices for land application of vegetable food-processing byproducts:

- Water does move through the soil profile, down to depths of 30 inches and beyond. The greater infiltration rates seem to occur in clean, well-sorted sands with little fines, and in dry and cracked clayey soils. Without amendment (e.g., a few months of moisture conditioning), these soils should be avoided for land-application. Soils with clear-water infiltration rates of 0.05 cm/min or more should be avoided when using flood irrigation. Alternative irrigation methods (e.g., sprinkler irrigation) would need to be assessed for these soils, by installing soil moisture sensors in a test plot and confirming that managed irrigation does indeed limit water propagation through the soil profile.

- Silty sands and sandy loam soils seem to have the lowest infiltration rates, and are recommended for land application. These granular soils are unlikely to crack and easily anneal if cracked or burrowed. Infiltration rates of 0.01 to 0.05 cm/min seem to offer a good compromise between reduced infiltration and good soil moisture release to plants.

- Measurement of infiltration rate with the procedure and equipment used in this study is a simple and inexpensive way to "rate" the suitability of a soil for land application of vegetable food-processing byproducts.

- Even silty sands will experience propagation of water down to the 30-inch depth if rainfall or irrigation exceeds precipitation or application rates of 1 inch/day. Chemical transport by these "break-through" events needs to be taken into account when evaluating potential impacts to groundwater. Measurement of soil moisture by sensors like the ones used in this study is a simple and inexpensive way to keep track of the behavior of water movement in any given type of soil.

- Temporary storage of thick "cakes" of vegetable slurries is not likely to cause undue amounts of infiltration, because the vegetable particles tend to seal the pores. Best performance can be expected from storage over silty sands and sandy loam soils, or over asphalt laid over silty sand soils. Storage over jointed concrete surfaces is not recommended, as the concrete slabs may "hide" cavities formed by burrowing animals.

1. INTRODUCTION

Intensive agriculture is generally accompanied by food-processing activities (e.g., canning) that generate residual byproducts such as culled produce, peach pits, stems and skins. These byproducts can be "recycled" into agricultural operations by applying them to soils where a new crop will be produced. To minimize environmental impact, however, good management practices have to be identified. The purpose of this paper is to report on data acquired through soil moisture sensors and double-ring infiltrometers, and to draw conclusions on the infiltration rates of irrigation water and interstitial byproduct fluid ("juice") through an initial set of representative soils.

A typical land application will include trucking in slurries of vegetable byproducts, and pouring them unto the land to form a thick (up to 12 inches) "cake". Under normal operating conditions the "cake" is immediately spread to an average depth of 1 inch, dried for a few days (so effectively most of the interstitial "juice" dries by evaporation, leaving behind a residue of inorganic salts and organic compounds), and is then disced into the topmost 6 inches of the soil profile before new seed is planted and a new crop grown. In the Central Valley of California the peak of the food-processing and land-application seasons is between July and November, and the new crop is grown as a winter crop between December and March (rye grass, alfalfa, and forage corn).

There are two basic scenarios that are of significance regarding potential environmental impact: (1) "Storage" to a depth of 12 inches of a slurry of byproducts directly on saturated soils or on asphalt for a few days before they are spread on a field. The concern here is that the 12-inch hydraulic head could drive the interstitial "juice" deep into the soil profile, so it could bypass the root zone and reach shallow groundwater. (2) Migration of residual inorganic salts and organic compounds left behind after spreading and drying, in response to repeated events of irrigation and/or winter rainfall.

2. CHARACTERIZATION OF THE VEGETABLE BYPRODUCTS

For this project we used two idealized types of byproduct slurries: The first one was a diluted mix of canned tomato paste. The diluted mix (hereafter referred to as tomato juice) was prepared on site, by mixing 6 kg of tomato paste (Chef's Review Tomato Puree with a specific gravity of 1.06 g/cm^3) with 38,000 cm^3 of clear water. The tomato juice thus prepared is a worst-case proxy for a cake of byproduct 12-inches thick; by choosing a "slurry" with a much lower solid content and viscosity we could thus estimate maximum possible rates for the fluids contained in a real vegetable byproducts slurry.

The second byproduct slurry we used was canned fruit cocktail (Polar Fruit Salad). This slurry was not used for the infiltration studies, but we make reference to it here because it was used in the mass transport study, which will be reported under different cover.

Liquefied fresh tomatoes (Tomato 1), liquefied canned tomatoes (Tomato 2), and a liquefied sample of the fruit cocktail (Fruit 1), were characterized in terms of field pH, Eh, and calculated ionizable Total Dissolved Solutes (ITDS). In addition, filtrates (i.e., separated interstitial "juice") of the three slurries were analyzed in the chemical laboratory for Total Dissolved Solutes (the residual left after drying at a temperature of 80 C), and Fixed Dissolved Solutes (FDS) (the residual left after firing to a temperature of 400 C). The loss during firing (i.e., TDS-FDS) is presumed to be residual organic compounds "burnt" at high temperature, and is referred to as Volatile Dissolved Solutes (VDS; VDS = TDS-FDS). The following table summarizes the results (Appendix 1):

Slurry	pH	Eh	ITDS	TDS	FDS	VDS	VDS
		µS	ppm	mg/l	mg/l	mg/l	% of TDS
Tomato 1	4.70	5,200	2,600	19,000	5,080	13,920	73%
Tomato 2	4.22	13,685	6,842	34,900	11,900	23,000	66%
Fruit 1	4.00	1,920	3,840	71,300	1,700	69,600	98%
Tomato 1 (dup)				11,600	4,600	7,000	60%
Tomato 2 (dup)				18,600	8,000	10,600	57%
Fruit 1 (dup)				66,700	1,367	65,333	98%

The available data is admittedly scattered, but the following conclusions can be reached:

- Natural tomatoes have a low pH and relatively high TDS. Ionizable TDS increases as TDS or FDS increase, but the sample is too small to allow for a meaningful correlation. Since ionizable TDS is easy to measure with a field probe, it would be advantageous to measure a larger number of materials to try to derive a meaningful correlation between field and laboratory measurements.
- Processed tomatoes have low pH values that are comparable to those of the natural tomatoes, but their TDS and FDS loads are nearly twice as large.
- For both natural and processed tomatoes the VDS load is between 60 and 70% of the TDS.
- Fruit cocktail has low pH values and very high TDS loads. However, most of the load is in the form of VDS, which is 98% of the TDS. The high values are not surprising, in that fruit has a naturally high content of sugar, and this content is considerably increased by the addition of syrup.

It seems reasonably to assume that microorganisms in the soil would consume the VDS load, so from the standpoint of potential load to groundwater the relevant parameter would be FDS, which from the table above could be expected to range between 1,000 and 12,000 mg/l in interstitial "juice".

3. CHARACTERIZATION OF SOILS

For our infiltration experiments we used four different types of soils (Appendix 2). The two letter designations are those of the Unified Soil Classification System (USCS).

Soil type	USCS	Uniformity coefficient (C_u=d_{60}/d/$_{10}$). A measure of sorting	Estimated porosity (based on data from the literature)	Estimated saturated hydraulic conductivity (cm/sec)
Soil 1. Fine sand. Aeolian sand from Ballico	SP	0.13/0.04 = 3.25 well sorted	30 to 40%	10^{-2} to 10^{-3}

Soil type	USCS	Uniformity coefficient (C_u=$d_{60}/d/_{10}$). A measure of sorting	Estimated porosity (based on data from the literature)	Estimated saturated hydraulic conductivity (cm/sec)
Soil 2. Fine sand with silt (loamy sand). Fluvial sand from Turlock	SW/SM	0.38/0.08 = 4.75 moderately sorted	20 to 30%	10^{-3} to 10^{-5}
Soil 3. Silty clay[1] from Merced. Fluvial	CH	NA	50-60%	10^{-6} to 10^{-8}
Soil 4. Silty clay[2] from Oakdale. Fluvial	CH	NA	50-60%	10^{-6} to 10^{-8}

[1] A dry, cracked soil. When ripped and dry, it forms sand-size aggregates coated with colloidal material, in effect behaving like a coarse-grained sand.
[2] A moist soil that had not been disced in one year.

For measurement of soil moisture profiles we used two different types of soils:

Soil type	USCS	Uniformity coefficient	Estimated porosity (based on data from the literature)	Estimated saturated hydraulic conductivity (cm/sec)
Soil 5. Fine sand with silt (sandy loam). Fluvial sand from Mapes Ranch	SW/SM	0.15/0.03 = 5.0 moderately sorted	20 to 30%	10^{-3} to 10^{-5}
Soil 6. Silty clay [1] from Dos Rios. Fluvial	CH	NA	50-60%	10^{-6} to 10^{-8}

[1] A soil that is ripped and disced every year prior to the winter planting. When ripped and dry, it forms sand-size aggregates coated with colloidal material, in effect behaving like a coarse-grained sand.

At this time we have not made a chemical characterization of the soils, but based on location and county-level soil surveys (Arkley, 1957; 1959; 1962; NRCS 2009) the different soils can be assigned to the following categories (see Appendix 2 for a summary of physical and chemical properties, as reported in the NRCS Web Soil Survey, http://websoilsurvey.nrcs.usda.gov/app/
:

Soil 1 – Delhi sand. These soils developed over former wind-blown sand dunes. They contain a high percentage of unweathered minerals, and provide a fair supply of mineral nutrients required by crops. Organic matter is very low, and nitrogen must be supplied for nonleguminous crops.
Soil 2 – Hanford sandy loam. These soils have good water-retention capabilities and moderate fertility. Slightly acidic.
Soil 3 – Wyman clay loam. These soils develop weak granular to blocky structural aggregates coated with colloidal material. They are hard when dry, sticky and plastic when wet, mildly alkaline, and have calcareous patches.
Soil 4 – Paulsell clay. Paulsell soils are dark, crack deeply, and granulate on the surface when dry. The surface soil tends to be slightly acidic, but the subsurface soil is neutral to slightly basic, and intermittently calcareous. Organic content is high.

Soil 5 –Fresno fine sandy loam (strongly saline-alkaline). These soils are permeated by alkaline salts. The subsoil has a columnar structure, and is underlain at depths of 2 to 3 feet by an impermeable, lime-silica cemented hardpan.
Soil 6 – Temple silty clay (moderately saline). Temple soils are characteristically gray to dark gray, have a high organic matter content, and are calcareous and slightly blocky in structure in the subsurface.

4. INFILTRATION EXPERIMENTS ON SOIL

We conducted infiltration measurements at four different soil sites (a fifth asphalt and concrete site is described in a later section). Three different double-ring infiltrometers were used at each soil site, for a grand total of 12 experiments.

Each of the double-ring infiltrometers consisted of two nested PVC cylinders, each 46 cm (18 inches) in height. The outermost cylinder had an internal diameter of 56.8 cm (22.35 inches). The innermost cylinder had an outside diameter of 45.5 cm (18 inches), and an internal diameter of 42.5 cm (16.7 inches).

To prepare for the experiment the soil was raked flat at three spots, approximately 10 feet apart. The inner ring was then pounded with a sledge hammer into the ground approximately 10 cm (4 inches). The outer ring then was carefully placed over the inner ring, and also pounded 10 cm (4 inches) into the ground. The soil inside the inner ring, and between the rings, was gently tamped down, to compensate for any loosening caused during the driving of the rings into the ground.

In general, we refer to the experiments by the names Infiltrometer A, Infiltrometer B, and Infiltrometer C. At any given site, the experiments were numbered, such that at Site 1 the infiltrometers are numbered 10, 11, and 12; at Site 2 they are numbered 1, 2, 3; at Site 3 they are numbered 4, 5, and 6; and at site 4 they are numbered 13, 14, 15. These are the numbers that appear in the data sheets of Appendix 3.

Infiltrometer A – Clear water throughout

Clear water was used throughout this experiment.

Phase 1. The experiment started by filling the annular space to a height of 30 cm (12 inches), and immediately filling the inner ring also to a height of 12 inches. This head was maintained by constant refilling throughout the constant-head phase (Phase 1) of the experiment. The experiment consisted on continuously replenishing both the inner ring and the annular space to keep a constant head of 30 cm, while timing the intervals between 500 cm^3 replenishments of the inner ring. In other words, every time 500 cm^3 were added to the inner ring the time was noted, in this way effectively measuring the rate of infiltration in the inner ring. The volumetric rates were converted to depth of infiltration by dividing over the cross-sectional area of the inner ring, and are shown as cumulative depth of infiltration in Figures 1, 4, 8, and 12. On any one of these figures, the derivative of the line defined by the data is the rate of infiltration. On the average, the constant-head portion of the experiment lasted about 200 minutes.

Phase 2. The next phase of the experiment consisted on allowing infiltration to continue without replenishing the lost volume. This is known as a falling-head experiment (Figures 2, 5, 9, and 13). The importance of this phase was that it further saturated the soil under the infiltrometer, in preparation for Phase 4 (Infiltrometer 1 was the control infiltrometer, so there was not a Phase 3 in it, as will become clear in the discussion of Infiltrometer 2). On the average, Phase 2 lasted 1,000 minutes.

Phase 4. The final phase of the experiment was a second falling-head experiment (Figures 7 and 11). The water level was replenished to 30 cm head, and allowed to drop in the same way as for Phase 2. In general, the falling-head curve for Phase 4 had a lower slope than that of Phase 2. The slower rate of infiltration for Phase 4 may be due to the fact that water that is already occupying the pores of the soil must be displaced to allow for new water to infiltrate, either by being "pushed" by the new water, or by gravity drainage. In either case, the presence of a former event of soil saturation (e.g., a heavy rain a few days prior) seems to lead to a slightly decreased rate of infiltration. On the average, Phase 4 lasted 1,500 minutes.

Infiltrometer B – Clear water for Phases 1 and 2, and tomato juice for Phases 3 and 4

For this experiment, clear water was used for Phases 1 and 2, and tomato juice for Phases 3 and 4.

Phase 1. This phase was identical to that described above for Infiltrometer 1. Results are summarized in Figures 1, 4, 8, and 12.

Phase 2. This phase was identical to that described above for Infiltrometer 1. Results are summarized in Figures 2, 5, 9, and 13.

Phase 3. The outer annular space was replenished with clear water to a head of 30 cm, and then the inner ring was replenished with tomato juice to a head of 30 cm. The tomato juice was prepared on site, by mixing 6 kg of tomato paste (Chef's Review Tomato Puree with a specific gravity of 1.06 g/cm^3) with 38,000 cm^3 of clear water. The tomato juice in this experiment is a worst-case proxy for a cake of food-processing by-product 12-inches thick; by choosing a "slurry" with a much lower solid content and viscosity we would thus estimate maximum possible rates for the fluids contained in a real vegetable by-products slurry.

This phase was conducted as a constant-head experiment, as described in Phase 1 above. Results are summarized in Figures 3, 6, 10, and 14. Comparing these results from those of Phase 1, shows that infiltration proceeded at a much slower rate when tomato juice was used, as would be expected from the clogging of soil pores by the particulate matter in the tomato juice (see the discussion on Infiltrometer 3 for further corroboration of this hypothesis).

Phase 4. The final phase of the experiment was a second falling-head experiment, but this time with the inner ring filled with tomato juice. Results are summarized in Figures 7 and 11. As can be seen by comparison of the results, the falling-head curves for Phases 2 and 4 are very different, which indicates that particulate matter in the liquid significantly reduces the infiltration rate. Note: Infiltration was so slow that we suspected evaporation might make a big difference. We measured evaporation at an average of 0.6 cm/day (0.00042 cm/min) using a simple plastic pan that stood at the site for two days. The evaporation rate is low, and for general evaluation purposes has but a minor effect in the calculation of infiltration rates (e.g., for one of the experiments the uncorrected infiltration rate is 0.0042 cm/min, whereas the corrected infiltration rate would be 0.0038 cm/min).

Infiltrometer C – Tomato juice for Phases 1 and 2

For this experiment, tomato juice was used for Phases 1 and 2. No Phases 3 or 4 experiments were conducted.

Phase 1. The experiment started by filling the annular space to a height of 30 cm (12 inches), and immediately filling the inner ring with tomato juice, also to a height of 12 inches. This head was kept throughout the constant head phase (Phase 1) of the experiment. The experiment consisted on continuously replenishing both the inner ring and the annular space to keep a constant head of 30 cm, while timing the intervals between 500 cm^3 replenishments of the inner ring. Initially the data are comparable to those of the other Phase 1 experiments, but over a matter of minutes becomes extremely flat (Figures 1, 4, 8, and 12). We believe that this is due to the fact that the particulate matter in the tomato juice "clogged" the pore spaces as the fluid moved quickly into the unsaturated soils. In effect, the clogged interface became a thin layer of very low hydraulic conductivity. Typically this phase of the experiment lasted about 500 minutes.

Phase 2. The next phase of the experiment consisted on allowing infiltration to continue without replenishing the lost volume, in a falling-head experiment. Not surprisingly, the data further showed the slow infiltration rate induced by clogging of the soil pores by the particulate matter of the tomato juice (Figures 2, 5, 9, and 13). Typically, after 1,000 minutes the head loss was less than 5 cm.

Results

The results of the various experiments are summarized in the following table, as infiltration rates in cm/min. The data are depicted in Figures 1 through 14, and are compiled in Appendix 3.

Soil 1. Fine sand. Aeolian sand from Ballico (SP).

Infiltrometer	Phase 1 – Constant head	Phase 2 – Falling head	Phase 3 – Constant head	Phase 4 – Falling head
A – Clear water	0.26 cm/min	0.18 cm/min	0.25 cm/min	
B – Water and tomato juice	0.17 cm/min	0.11 cm/min	0.08 cm/min	
C – Tomato juice	0.05 cm/min	0.01 cm/min		

Soil 2. Fine sand with silt (loamy sand). Fluvial sand from Turlock (SW/SM).

Infiltrometer	Phase 1 – Constant head	Phase 2 – Falling head	Phase 3 – Constant head	Phase 4 – Falling head
A – Clear water	0.036 cm/min	0.02 cm/min		0.01 cm/min
B – Water and tomato juice	0.039 cm/min	0.02 cm/min	0.01 cm/min	0.002 cm/min
C – Tomato juice	0.002 cm/min	0.001 cm/min		

Soil 3. Silty clay from Merced. Fluvial (CH).

Infiltrometer	Phase 1 – Constant head	Phase 2 – Falling head	Phase 3 – Constant head	Phase 4 – Falling head
A – Clear water	0.08 cm/min	0.03 cm/min		
B – Water and tomato juice	0.17 cm/min	0.08 cm/min	0.02 cm/min	0.001 cm/min
C – Tomato juice	0.009 cm/min	0.001 cm/min		

Soil 4. Silty clay from Oakdale. Fluvial (CH).

Infiltrometer	Phase 1 – Constant head	Phase 2 – Falling head	Phase 3 – Constant head	Phase 4 – Falling head
A – Clear water	0.02 cm/min	0.01 cm/min	0.01 cm/min	
B – Water and tomato juice	0.07 cm/min	0.04 cm/min	0.01 cm/min	
C – Tomato juice	0.01 cm/min	0.006 cm/min		

Discussion

Sands

The results for soils 1 and 2 document the difference in infiltration rates between a well-sorted sand (Ballico – SP), and a poorly-sorted sand (CSUS – SW/SM). The infiltration rate of clear water in the Ballico sand is nearly twice as large as that of the CSUS sand. The same order-of-magnitude difference holds true when tomato juice was used. The infiltration rates measured using tomato juice are at least an order of magnitude lower than those measured using clear water, but once again the ones measured in the Ballico sand are 10 times larger than those measured in the CSUS sand.

For the Ballico sand, the infiltration rate measured using clear water for both phases 1 and 3 (Infiltrometer A) is comparable, which suggests that infiltrating water was freely draining into lower soil levels. The difference in Phase 1 infiltration rate between infiltrometers A and B is probably due to small scale variations in the topmost few inches of the soil.

The sharp decrease in infiltration rate when tomato juice is used suggests that the suspended particles clog the pores in the soil, effectively creating a biofilm with very low hydraulic conductivity. For the two sand samples, the effect is most pronounced when comparing initially dry soil conditions (e.g., Phase 1 results from infiltrometers A and C), and less pronounced when the tomato juice is applied to a previously wetted soil (e.g., Phase 1 and Phase 3 results for infiltrometer B). This suggests to us that the speed of initial infiltration might play a role in the packing of suspended solids in the pores of the soil. In the initially dry condition, capillary forces would be added to hydraulic head to promote an initially fast rate of infiltration (note, for example, the steepness of the initial portions of the curves in Figures 1 and 4), and tighter packing of the suspended solids. In the previously wetted case, however, the capillary forces would be negligible, so the suspended solids would "settle" over the pores rather than be forced into them (note, for example, the constant rate of infiltration for the Phase 3 experiments in Figures 3 and 6).

The falling head experiments yield long-term infiltration rates that are an order of magnitude smaller than those of the constant head experiments. This is not surprising given that previous wetting during the constant head experiments would have eliminated capillary forces, and progressively lower hydraulic heads would progressively reduce the driving forces.

Clays

The results for soils 3 and 4 document the difference in infiltration rates between a dry, cracked silty clay (Merced – CH), and a moist silty clay that has not been allowed to dry and crack over a period of nine months (Oakdale – CH). The dry and cracked Merced soil forms sand-size aggregates coated with colloidal material, in effect behaving like a coarse-grained sand. The Oakdale soil, in contrast, behaves like a typical clay, but this is an artifact of the long period of "moisture conditioning" since it had been ripped and planted nine months prior. We have used the Oakdale soil in other experiments, and it too cracks when dry to form sand-size aggregates.

The Merced soil had clear-water infiltration rates that were even higher than those measured in the Ballico sand, on account of the coarse aggregates. However, infiltration rate dropped down dramatically when tomato juice was used (compare, for example, the Phase 1 results for infiltrometers A and C), probably because fast infiltration rates forced suspended solids into the cracks and packed them tightly. Like for the sands, the lowering of infiltration rate was less pronounced when the soil was pre-wetted by the Phase 1 experiment (compare, for example, the Phase 1 and Phase 3 results for infiltrometer B).

The Oakdale soil behaved, in all respects, in the way one would expect from a conditioned clay. Measured infiltration rates were equally low for the clear-water and tomato juice experiments, and pre-wetting had at best a trivial effect.

Advance of the moisture front into the soil profile

We excavated a few of the lysimeters after the experiments were concluded, and took samples at different depth intervals to determine their moisture content (by weight) and electric conductivity. We also collected samples from an unwetted control pit. The purpose of this sampling was to try to determine the depth of advance of the infiltrating water into the soil profile.

The samples were weighted at their field water content, dried in an oven, and then weighted again. The weight of water was determined by difference, and the moisture content (m) was calculated as m = weight of water/weight of dry solids. Once the soil was dry, we took a 100 g split, and "washed" it with 100 ml of deionized water. After shaking the mixture for a few minutes we measured the electric conductivity of the fluid using a Hanna 991300 pH-EC meter.

The depth vs. moisture and depth vs. electric conductivity for each site was plotted, to see if we could identify, either by moisture content or by electric conductivity, the maximum advance of the infiltration front. The data thus acquired are plotted in Figures 15 through 19, and are compiled in Appendix 4.

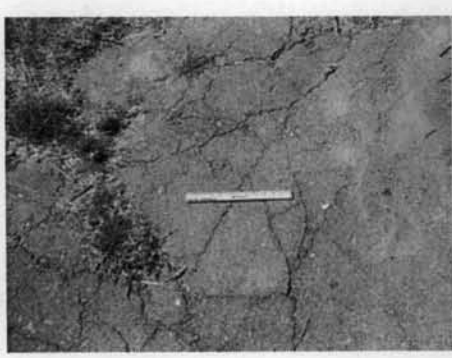
The data from the Ballico sand suggests a maximum advance of 12 inches for the tomato juice infiltration front (infiltrometer C in Figure 16), and 20 inches for the clear water followed by tomato juice infiltration front (infiltrometer B in Figure 16). These extents of advance are consistent with a porosity of 0.3, which is reasonable given the nature of the eolian sand.

The data for the CSUS sand is more limited, but suggests a maximum advance of only 10 inches for the tomato juice infiltration front (Figures 17 and 18).

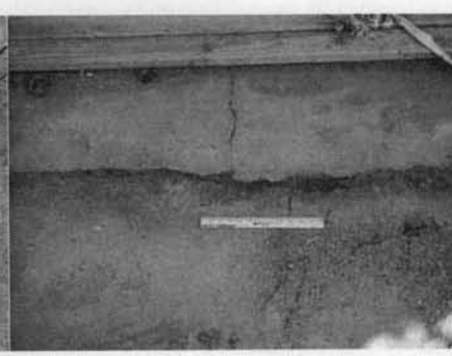
The data for both clay soils is inconclusive.

5. INFILTRATION EXPERIMENTS ON ASPHALT AND CONCRETE

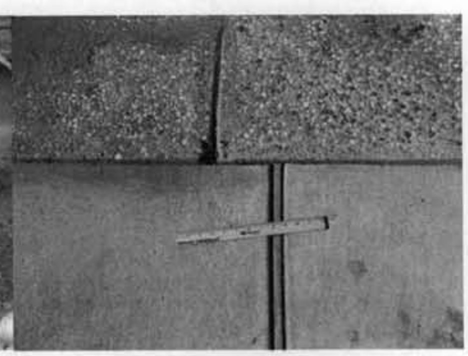
Two infiltration experiments were conducted on cracked asphalt (3 inches thick) that covers silty sand (SM), and one on jointed concrete (6 inches thick) that covers silty sand (SM). The following photographs illustrate these surfaces:



Asphalt 1



Asphalt 2



Jointed concrete

For every site, the inner and outer rings were "glued" in place using silicon caulk. The bond with Asphalt 2 had to be caulked a second time, because the large crack running from left to right through the center of the photograph is depressed, and the original seal leaked.

The jointed concrete site presented considerable difficulties. The joints are used by a colony of ants, which apparently has tunneled extensively under the concrete slab. The silicon seal between the rings and the concrete was very good, even directly under the joints, but water from the outer ring simply flowed under the seal and "bubbled" out a few inches from the joint. We caulked the joints for a length of about 6 inches away from the outer ring, and diminished the extent of the leakage, but had to accept a significant amount of water loss farther along the joints.

For this set of experiments we followed the same pattern as with the soil experiments, except that we only had the equivalent to Infiltrometer B. The data are presented in Appendix 5, and the results are summarized as follows:

Infiltrometer B – Clear water for Phases 1 and 2, and tomato juice for Phase 3

For this experiment, clear water was used for Phases 1 and 2, and tomato juice for Phase 3.

Phase 1. The experiment started by filling the annular space to a height of 30 cm (12 inches), and immediately filling the inner ring also to a height of 12 inches. This head was maintained by constant refilling throughout the constant-head phase (Phase 1) of the experiment. The experiment consisted on continuously replenishing both the inner ring and the annular space to keep a constant head of 30 cm, while timing the intervals between 500 cm^3 replenishments of the inner ring. In other words, every time 500 cm^3 were added to the inner ring the time was noted, in this way effectively measuring the rate of infiltration in the inner ring. The volumetric rates were converted to depth of infiltration by dividing over the cross-sectional area of the inner ring, and are shown as cumulative depth of infiltration in Figure 23. On this figure, the derivative of the line defined by the data is the rate of infiltration.

Phase 2. The next phase of the experiment consisted on allowing infiltration to continue without replenishing the lost volume. This is known as a falling-head experiment (Figure 24). The importance of this phase was that it further saturated the soil under the infiltrometer, in preparation for Phase 3.

Phase 3. The outer annular space was replenished with clear water to a head of 30 cm, and then the inner ring was replenished with tomato juice to a head of 30 cm. The tomato juice was prepared on site, by mixing 6 kg of tomato paste (Chef's Review Tomato Puree with a specific gravity of 1.06 g/cm^3) with 38,000 cm^3 of clear water. For the jointed concrete site, the tomato juice proved to be undistinguishable from clear water, probably on account of the large size of the ant tunnels, so we repeated the experiment using a mix of 6 kg of chopped tomatoes and 38,000 cm^3 of clear water.

This phase was conducted as a constant-head experiment, as described in Phase 1 above. Results are summarized in Figure 25. Comparing these results from those of Phase 1, shows that infiltration proceeded at a much slower rate when tomato juice was used (or chopped tomatoes in the case of the jointed asphalt site), as would be expected from the clogging of soil pores by the particulate matter in the tomato juice.

Results

The results of the various experiments are summarized in the following table, as infiltration rates in cm/min. The data are depicted in Figures 23 through 25, and are compiled in Appendix 5 (The Asphalt 1 site is identified in the appendix as Infiltrometer 7, the Asphalt 2 site as Infiltrometer 9, and the Jointed Concrete site as Infiltrometer 8).

Asphalt 1. 3-inch thick asphalt, laid down 30 years ago. Numerous thin cracks.

Infiltrometer	Phase 1 – Constant head, clear water	Phase 2 – Falling head	Phase 3 – Constant head, tomato juice
B – Water and tomato juice	0.19 cm/min	0.06 cm/min	0.01 cm/min

Asphalt 2. 3-inch thick asphalt, laid down 30 years ago. Two large cracks.

Infiltrometer	Phase 1 – Constant head, clear water	Phase 2 – Falling head	Phase 3 – Constant head, tomato juice
B – Water and tomato juice	0.5 cm/min	0.17 cm/min	0.03 cm/min

Jointed concrete. Four intersecting joints in 6-inch thick concrete, poured 30 years ago. Numerous ant tunnels under the concrete

Infiltrometer	Phase 1 – Constant head, clear water	Phase 2 – Falling head	Phase 3 – Constant head, tomato juice or chopped tomatoes
B – Water and tomato juice	22.0 cm/min	Too fast to measure	10.5 cm/min
B – Water and chopped tomatoes			0.03 cm/min

Discussion

The clear-water data from the two asphalt locations is higher than the equivalent data from say Soil 2 (SW/SM), even though both asphalt locations are underlain by SM soils. This may be due to the fact that old cracks in the asphalt propagate down into the soil. Clearly, the through-going cracks of Asphalt 2 yield higher infiltration rates than those yielded by the network of minor cracks present in Asphalt 1.

Significantly, however, the Phase 3 rates are comparable between the two asphalt sites, and those of Soil 2. Once again, clogging of the soil pores by the suspended particles is suspected, and apparently is just as efficient in the cracks as it is in the granular pore space of the sandy soils.

The infiltration rates in the jointed concrete are enormous, as could be expected from the fact that water is moving through tubular ant galleries. The presence of suspended solids in the tomato juice of Phase 3 has but little effect in the infiltration rate, which in our opinion corroborates the fact that the channels through which the fluid is moving are larger than the "pores". When we used chopped tomatoes, however, there was a dramatic decrease in infiltration rate. The chopped tomatoes have characteristic sizes in the range of 1 to 10 mm, which is apparently sufficient to clog the ant galleries. We note a slight increase in infiltration rate in the last three data points of the jointed concrete with tomato pieces graph in Figure 25, and speculate that it may have been the result of incipient washing out of the obstructions under the high hydraulic head.

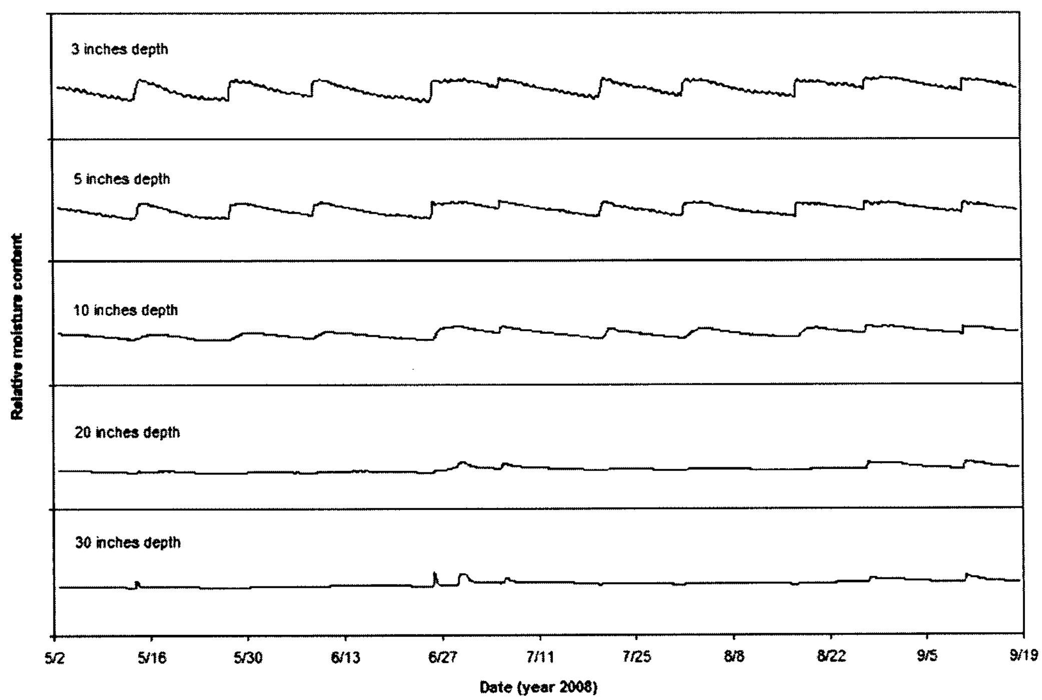
6. IN SITU MEASUREMENT OF SOIL MOISTURE INFILTRATION FRONTS

On December 1, 2006, we installed two different stacks of moisture sensors, one at Mapes Ranch and another in Dos Rios Ranch. The Mapes Ranch site is located at 37.65N 121.19W, in fine sand with silt (sandy loam; SW/SM), at the same location as Meteorologic Station 71 of the California Irrigation Management System. The Dos Rios Ranch is located at 37.59N 121.15W, in silty clay (CH).

Each stack consists of five Decagon soil moisture sensors (Model EC-20), buried horizontally at progressively deeper depths within the soil profile. In both cases a pit 2 ft in diameter was dug to a depth of 30 inches, and the sensors were placed at the desired depth as the pit was backfilled. Each "lift" was slightly tamped by hand, to simulate the horizontal stratification of the original soil profile. Since the profile had been disturbed, the sensors were left in place for a minimum of 6 months before the first measurements were taken.

Mapes Ranch – Fine sandy loam covered with pasture grass

The data-logger at Mapes yielded a very useful set of data from all five probes for the 2008 irrigation season. The data are summarized in the following graph (see also Figure 26):



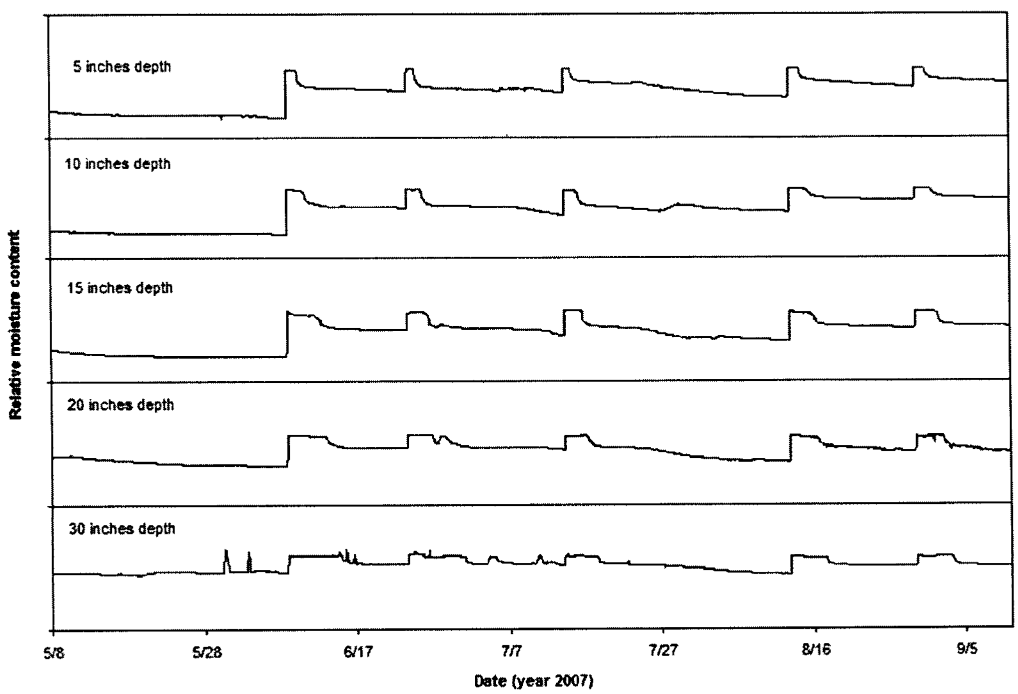
Each graph represents relative soil moisture, in volume percent. Moisture values are as low as 29.0% (field capacity) and as high as 48.0% (full saturation), with typical values being around 35% for the 3", 5", 10", and 20" probes. The bottom-most probe, at 30" depth, lies almost on top of a layer of hard pan, and has typical moisture values that are close to saturation, at about 40%.

As the graph shows, moisture fronts due to irrigation (marked by the sudden increases in moisture values of the 3" probe), propagate rapidly to 5-inch and 10-inch depths, Taking the derivative of the data allows one to estimate the advance rate of the moisture front at about 9 in/hour between the 3" and 10" depth intervals, 3 in/hour between the 10 and 20" depth intervals, and 2.5 in/hour between the 20 and 30" intervals (based on the 8/26/08 irrigation event).

The relatively "flat" profile of the 30" probe can be interpreted in two different ways. The first possible interpretation is that, because the soil at this depth is close to saturation (the probe sits on top of a hard pan layer), the lack of response could be simply due to the fact that there is not enough storage, S, available for the infiltrating water to move in. A possible second interpretation is that the roots of the grass are efficiently removing the moisture before it has the chance to infiltrate down to the 30" level, except for occasional "break-through" caused by unusually high irrigation heads (e.g., the 6/26/08 and 8/26/08 events).

Dos Rios – Clayey soil with annual crop cover

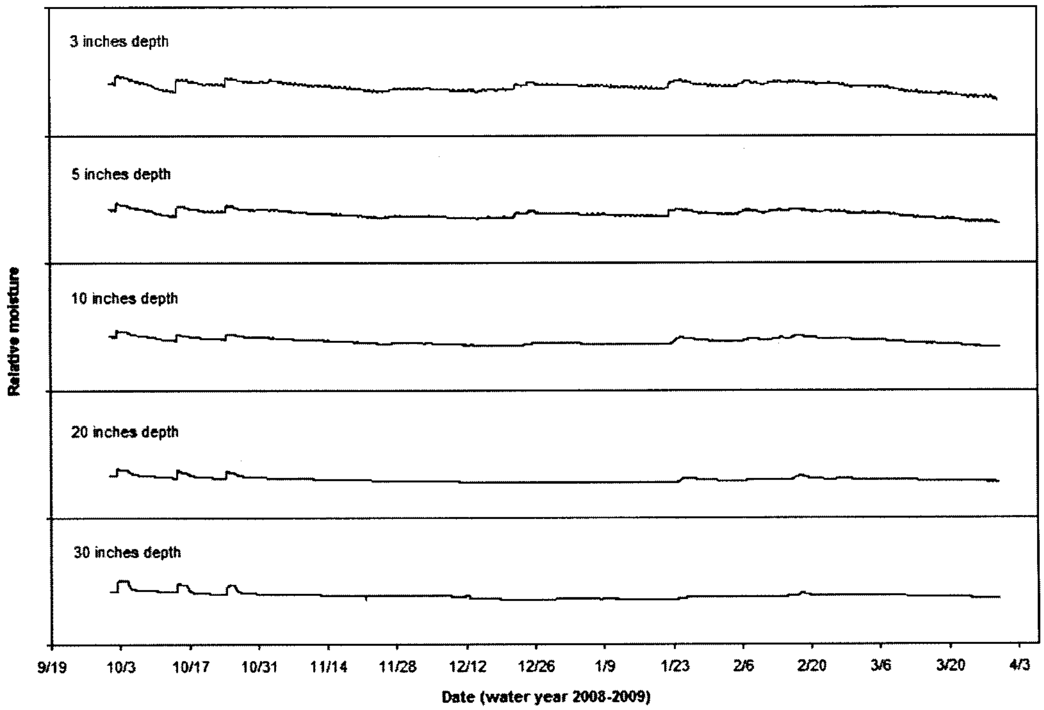
The data-logger at Dos Rios was knocked down from the pole where it was mounted sometime in late 2007. Unfortunately this allowed moisture to enter the data-logger, which in turn rusted the batteries and terminals. We retrieved the logger, reconstructed the terminals and cleaned the rusted pins of the transistors, and were able to retrieve data collected during the 2007 irrigation. The data thus covers the same time of the year as the Mapes Ranch data, but for a different year. The data from this silty clay (CH) site is very surprising (see also Figure 27):



Quite clearly moisture moves quickly through this soil profile. The rate is 30 in/hour, which is considerably higher than the 2.5 to 10 in/hour documented in Mapes Ranch. The depth of penetration is also larger, with most events propagating to the 30-inch depth. Surprising as the high values are for a clayey soil, they are consistent wit the results we obtained from the infiltration experiments in dry, cracked clay. The explanation is probably the same: As the clayey soils are ripped and disced they break into small peds with size ranges from 1 to 10 mm. From that point onward the soils behave more as sandy gravels than clays.

Rainy season observations

We collected data for the rainy season, from October 1 2008 to March 30 2009, at the Mapes Ranch site. The graphs are not spectacular, as shown in the figure below (see also Figure 28). During October, the site received three applications of irrigation water, and the moisture propagated all the way to the 30 inch depth. The rate was 7 in/hour between the 3" and 10" depth intervals, 10 in/hour between the 10 and 20" depth intervals, and 5 in/hour between the 20 and 30" intervals (based on the 10/2/08 irrigation event).



November and December were comparatively dry months, with minor precipitation events happening on 11/26 (0.25 inches of precipitation measured at the CIMIS station), 12/14 to 12/15 (0.3 inches), 12/21 to 12/22 (0.3 inches), and 12/24 to 12/25 (0.47 inches). To judge from the small disturbances in the graphs these events did not propagate past the 10 inch depth.

January was also comparatively dry, but from 1/21 to 1/25 the CIMIS station recorded a total of 1.58 inches of precipitation. This event was clearly large enough to propagate down to the 30 inch depth.

February precipitation was significant on 2/5 to 2/6 (0.59 inches), 2/11 to 2/13 (0.51 inches), and 2/15 to 2/17 (0.92 inches). The latter event was significant enough to propagate down to the 30 inch depth.

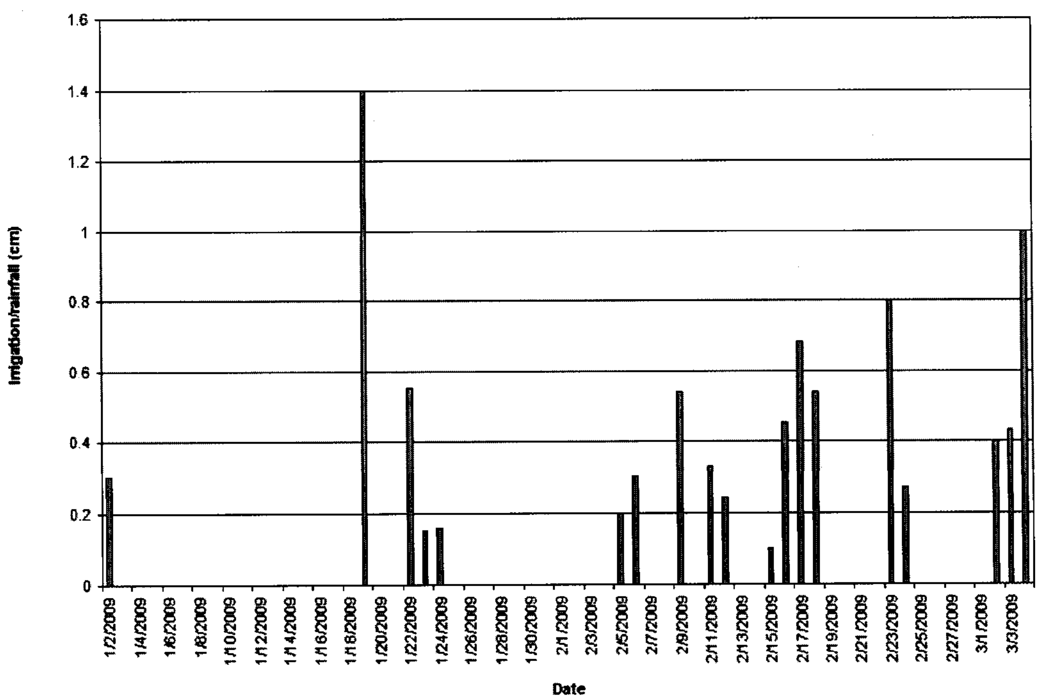
March precipitation was only significant on 3/1 to 3/4 (0.37 inches). The March data show a general decline in moisture content at the 3, 5 and 10-inches depths, reflecting the extraction of soil moisture by the emergent pasture grasses.

Lysimeter data

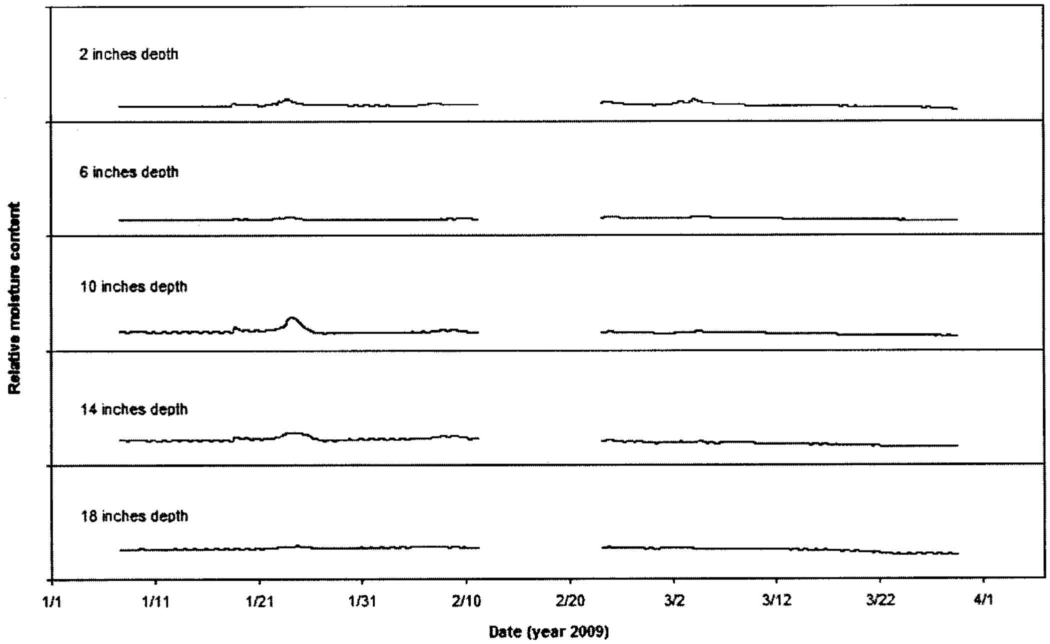
As part of Phase 2 of this project we have installed depth sensors in two lysimeters. The lysimeters are 18 inches in diameter and 24 inches tall. One of them is filled with CSUS fine sand with silt (loamy sand; SW/SM), and the other is filled with Oakdale silty clay (CH). The clay was excavated, and sieved to remove pieces larger than 1 cm, so for the first few months would be expected to behave as a coarse sand, rather than a clay.

Both lysimeters have bottom drains, which are normally kept open so the soils can drain naturally and remain at field capacity. On selected occasions, however, we have purposefully "irrigated" them with 2,000 ml, and have collected the drainage water using a 1,000 ml flask. Drainage was irregular during the first couple of months (October and November, 2008), particularly in the CSUS sand lysimeter, but after that time both the CSUS sand and the Oakdale clay lysimeters have consistently started draining within 24 hours, and have drained at least 1,000 ml of water in a matter of 5 days. Clearly, irrigation water is breaking through the 24 inch depth at a rate of 1 inch per hour or greater.

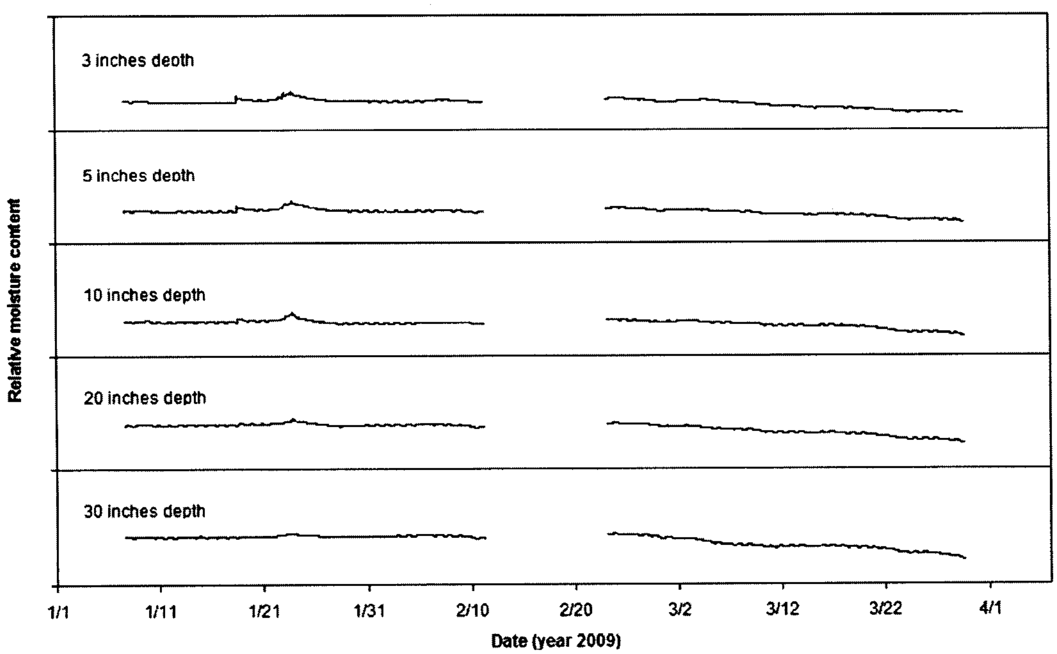
The following figure summarizes the irrigation/rainfall totals over the last three months (see also Figure 29):



The moisture sensor data collected from the lysimeters is not as consistent as that collected from the field stations. For example, for the CSUS sand lysimeter, "irrigation" and rain events took place on several occasions, but except for the 1/22 to 1/24 event (0.33 inches of rain) the data does not suggest extensive propagation of soil moisture fronts (see also Figure 30):



The Oakdale clay lysimeter data is not much different, except that both the 1/19 and 1/22 to 1/24 events seem to have propagated all the way down to the bottom of the profile (see also Figure 31):



The graphs above show an interesting "drift" toward lower values during the month of March, which is when most of the rye grass growth took place. It would seem that the vegetation is effectively removing moisture from the soil profile, even down to the 18-inches depth.

At this time we don't have a good explanation for the fact that migration of the moisture fronts is not well represented in the sensor data, even though significant drainage has been measured. A possibility is equilibrium water transport through soils that remain at field capacity, in which the amount being added through irrigation is balanced by the amount being drained, without a net increase in the water present at any given time.

7. BEST MANAGEMENT PRACTICES BASED ON INFILTRATION STUDIES

The purpose of this research effort is to present recommendations to minimize the environmental impact of land application of vegetable food-processing byproducts. Taking in consideration the results from the infiltration experiments and the soil moisture probes, we suggest the following best management practices:

- Without amendment (e.g., a few months of moisture conditioning), these soils should be avoided for land-application. Soils with clear-water infiltration rates of 0.05 cm/min or more should be avoided when using flood irrigation. Alternative irrigation methods (e.g., sprinkler irrigation) would need to be assessed for these soils, by installing soil moisture sensors in a test plot and confirming that managed irrigation does indeed limit water propagation through the soil profile.

- Silty sands and sandy loam soils (SW, SM, ML) seem to have the lowest infiltration rates, and are recommended for land application. These granular soils are unlikely to crack and easily anneal if cracked or burrowed. Infiltration rates of 0.01 to 0.05 cm/min seem to offer a good compromise between reduced infiltration and good soil moisture release to plants.

- Measurement of infiltration rate with the procedure and equipment used in this study is a simple and inexpensive way to "rate" the suitability of a soil for land application of vegetable food-processing byproducts.

- Even silty sands will experience propagation of water down to the 30-inch depth if rainfall or irrigation exceeds precipitation or application rates of 1 inch/day. Chemical transport by these "break-through" events needs to be taken into account when evaluating potential impacts to groundwater. Measurement of soil moisture by sensors like the ones used in this study is a simple and inexpensive way to keep track of the behavior of water movement in any given type of soil.

- Temporary storage of thick "cakes" of vegetable slurries is not likely to cause undue amounts of infiltration, because the vegetable particles tend to seal the pores. Best performance can be expected from storage over silty sands and sandy loam soils (SW, SM, ML), or over asphalt laid over silty sand soils. Storage over jointed concrete surfaces is not recommended, as the concrete slabs may "hide" cavities formed by burrowing animals.

8. ACKNOWLEDGMENTS AND CLOSURE

The work summarized in this report was performed by Prof. Horacio Ferriz, and students Timothy Holling, Amanda Reinheart, and Tamera Rogers, all from California State University Stanislaus. The students will use all or part of this study to prepare senior theses and/or research abstracts to be presented at professional meetings. Peer review was provided by Dr. Sajeemas (Mint) Pasakdee, Soil Scientist with the California Agricultural Technology Institute; Dr. Charles Krauter, Professor of Soils and Water Science at CSU Fresno; Ms. Vicki Jones, Senior Resource Management Specialist with the Stanislaus County Department of Environmental Resources; and Mr. Nat Dellavalle, Soil Scientist with Dellavalle Laboratories. Their thoughtful input is gratefully acknowledged.

This report is based on the field experiments described above. Prof. Horacio Ferriz should be notified if conditions are found to differ from those assumed herein, since this may require reevaluation of the conclusions and recommendations. This report has been prepared in accordance with generally accepted geologic practices and makes no other warranties, either express or implied, as to the professional advice or data included in it.

Sincerely,

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FIGURES

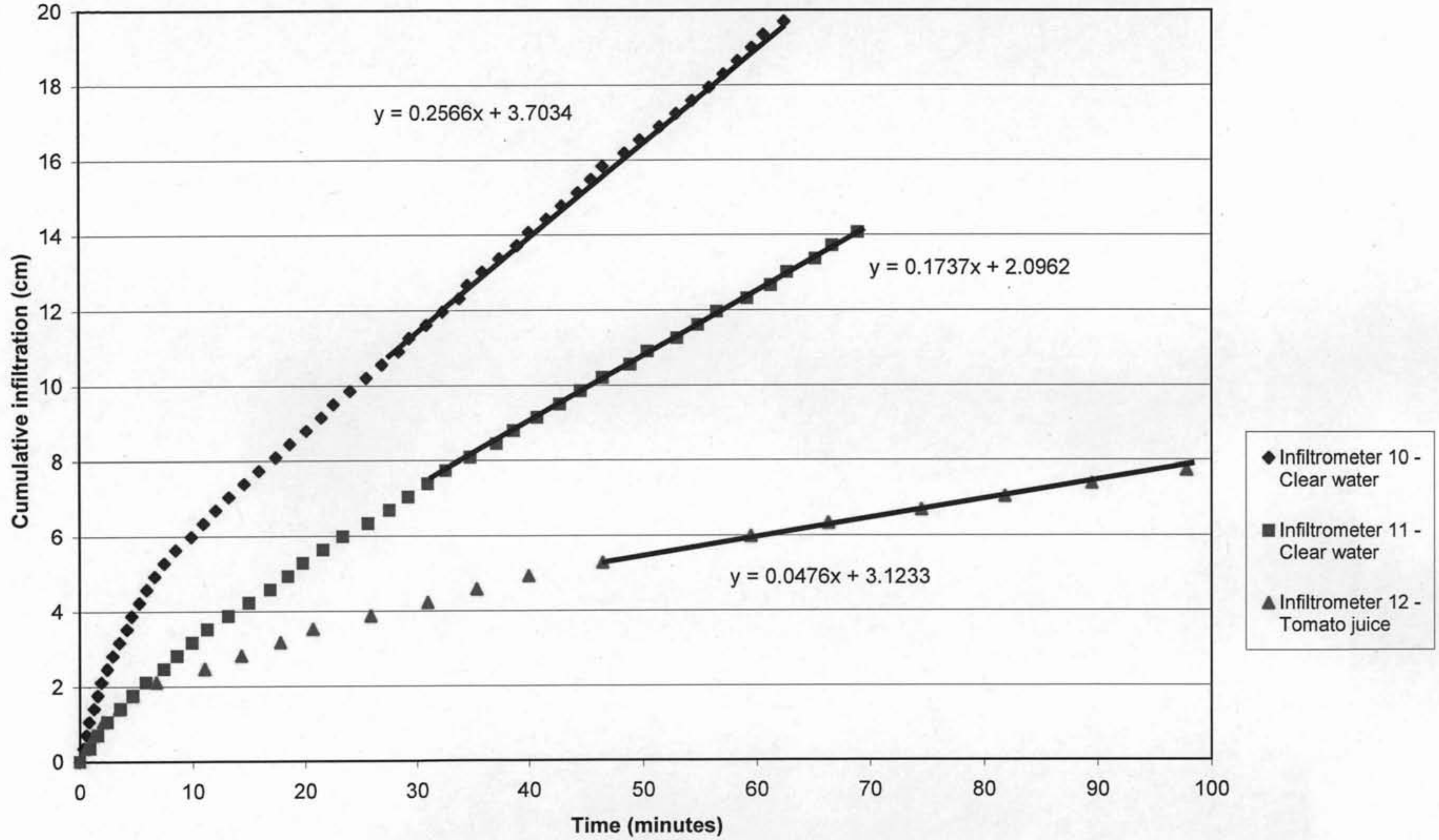


Figure 1. Soil 1 - Ballico sand (SP). Phase 1 data - Constant head experiment.

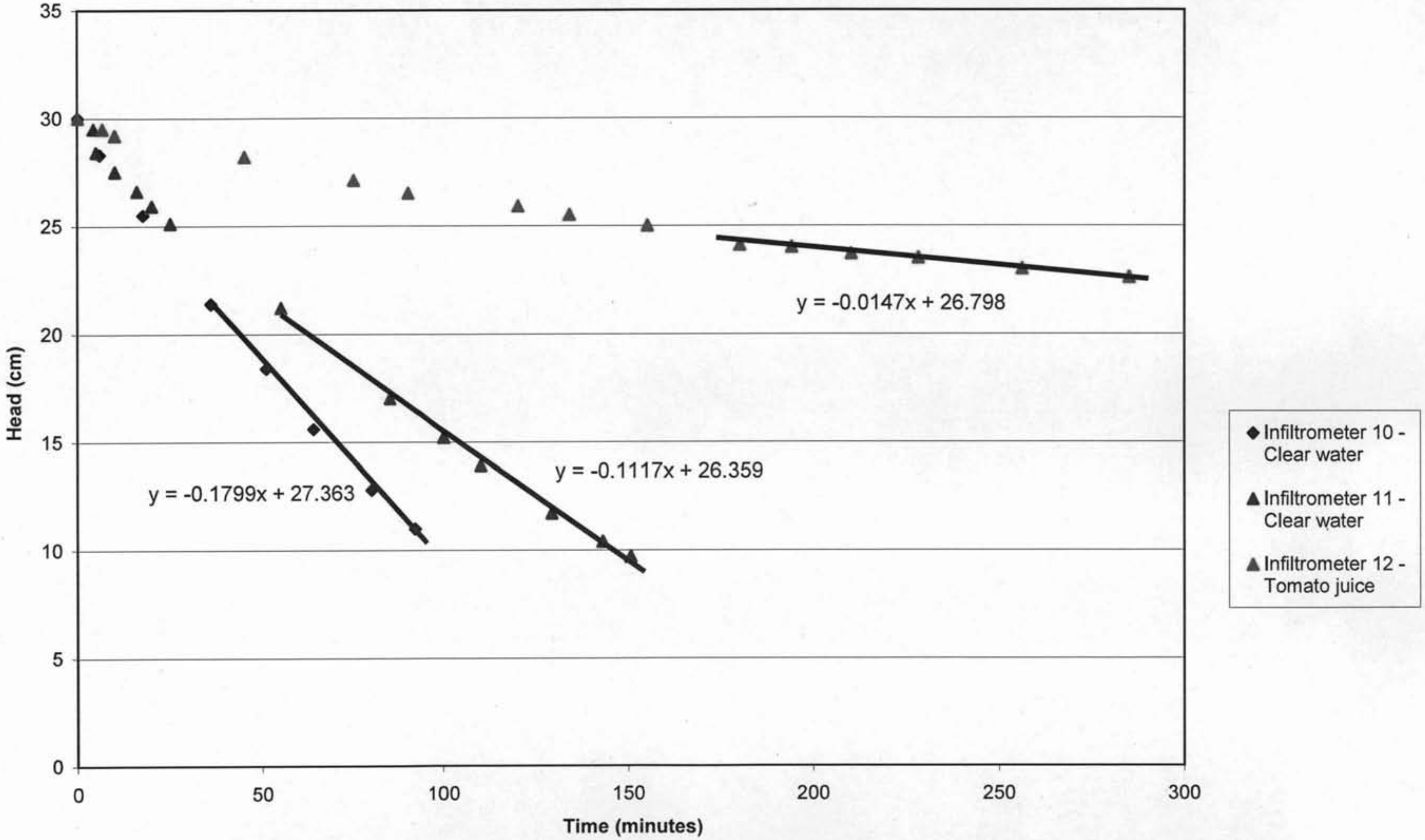


Figure 2. Soil 1 - Ballico sand (SP). Phase 2 data - Falling head experiment.

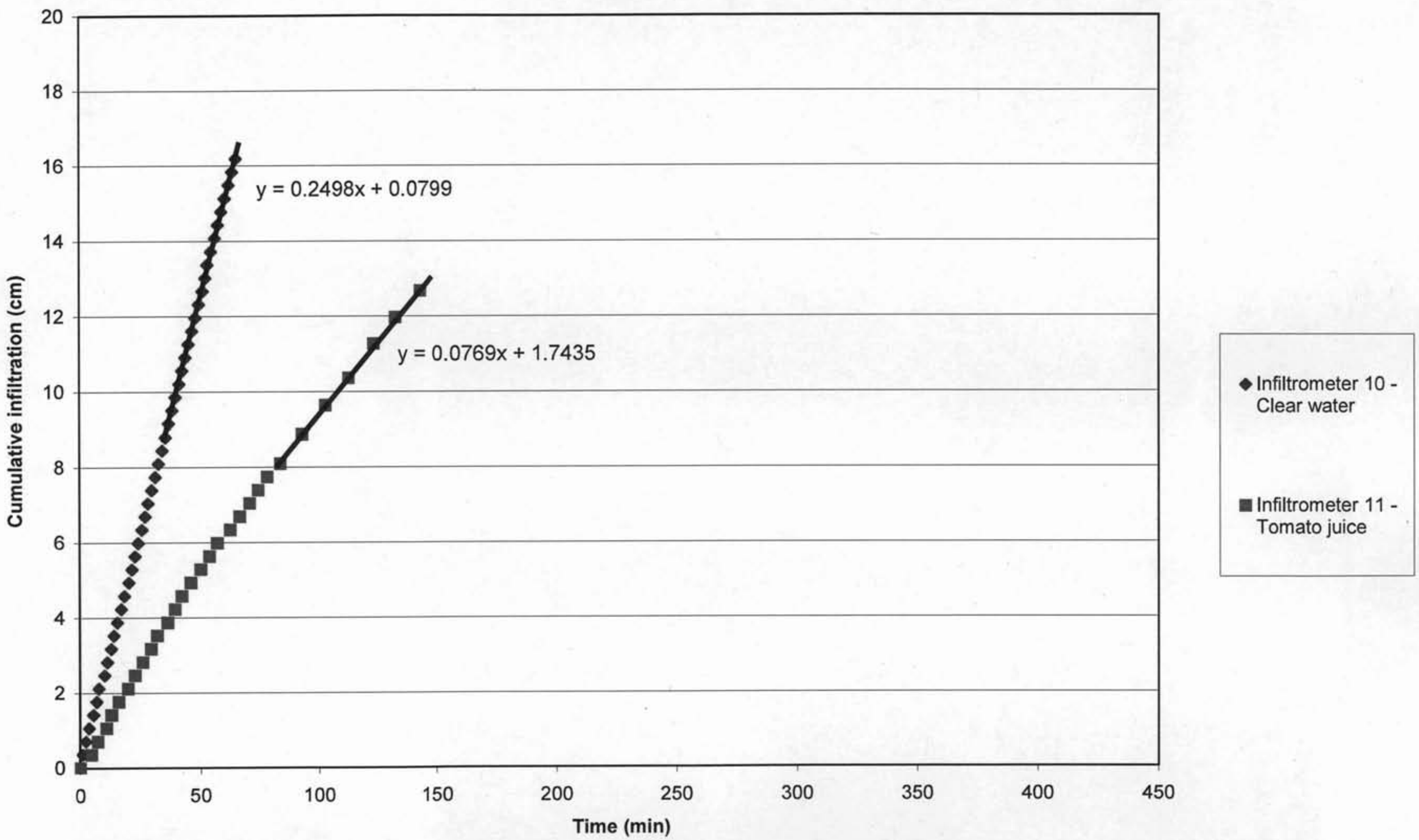


Figure 3. Soil 1 - Ballico sand (SP). Phase 3 data - Constant head experiment.

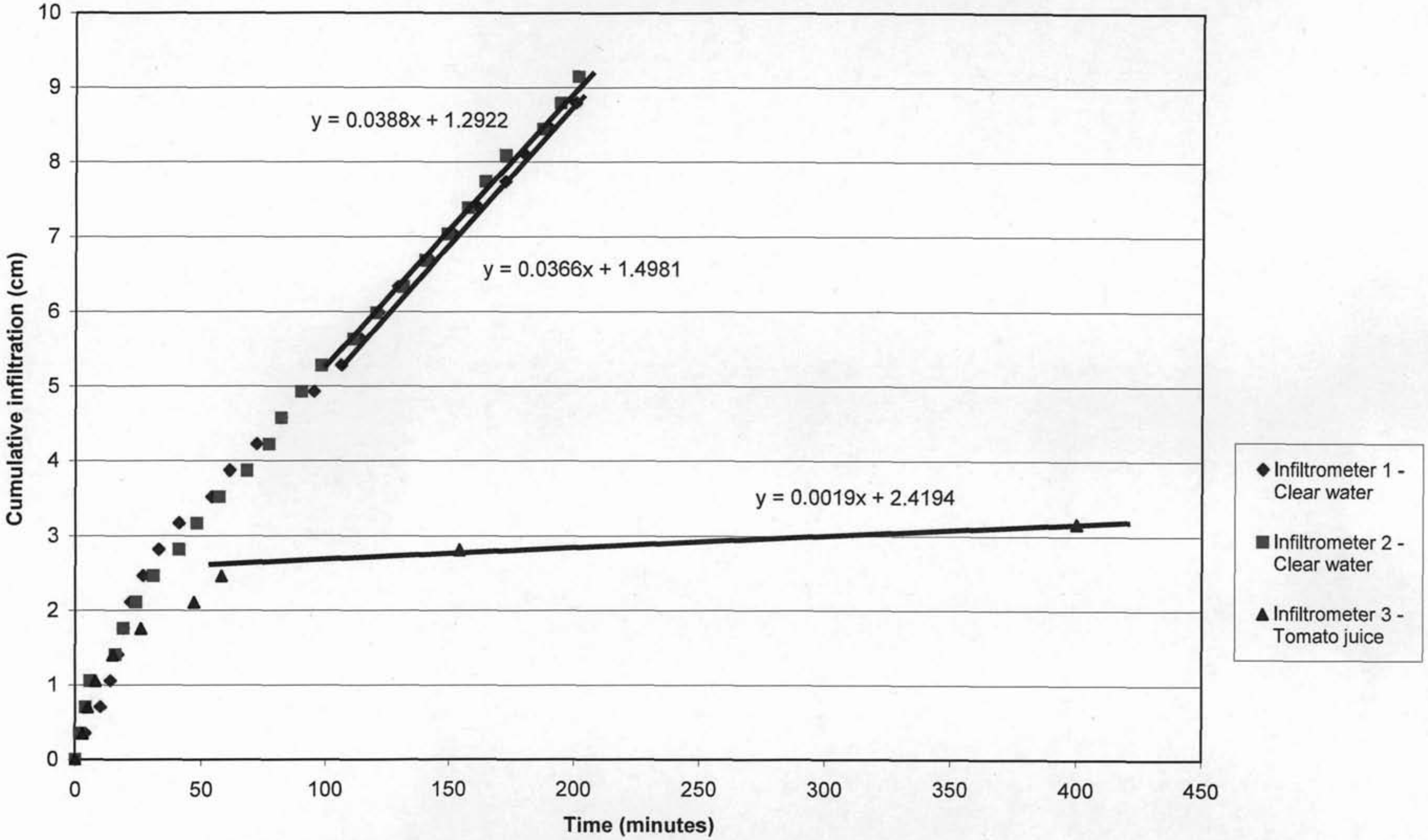


Figure 4. Soil 2 - CSUS sand (SW/SM). Phase 1 data - Constant head experiment.

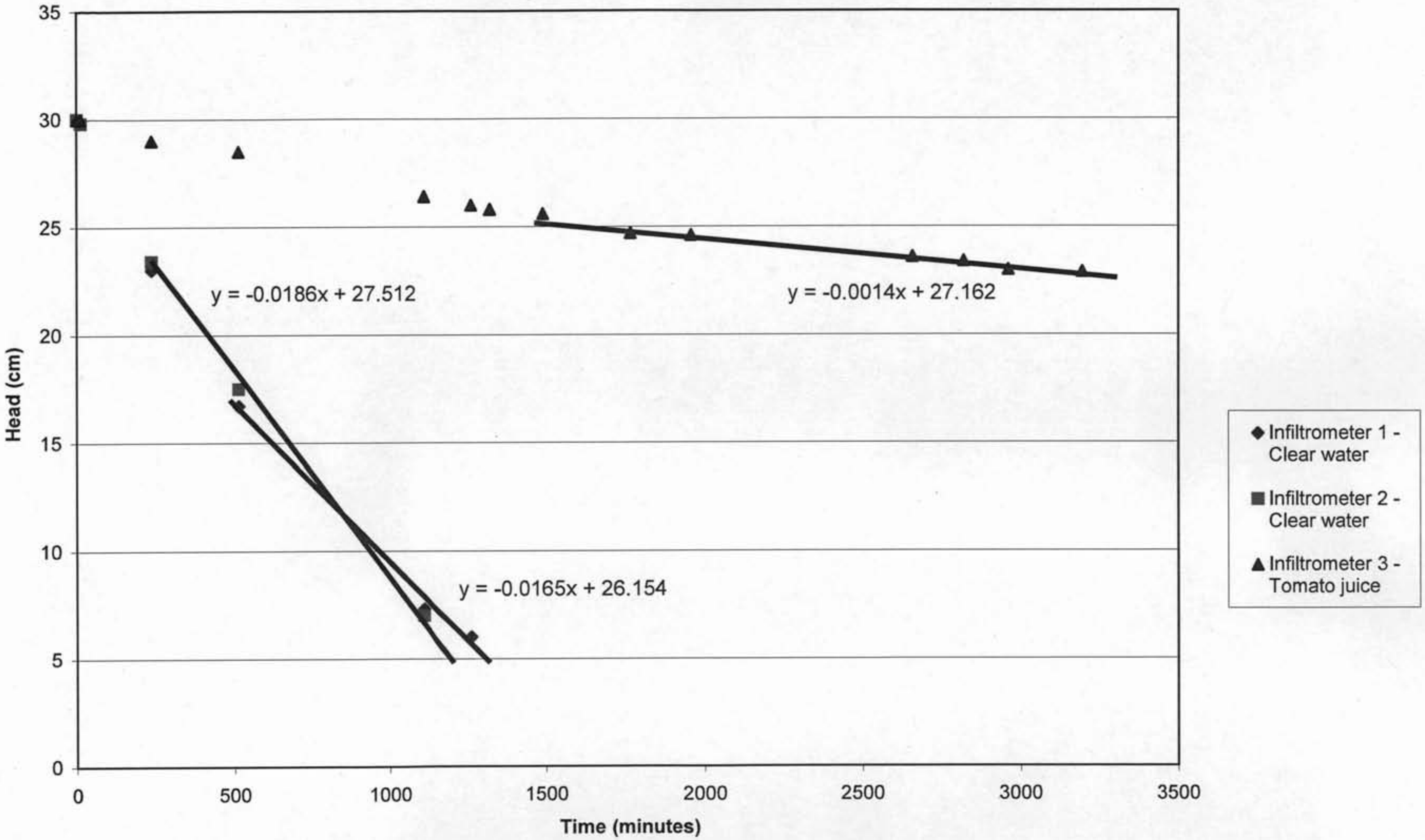


Figure 5. Soil 2 - CSUS sand (SW/SM). Phase 2 data - Falling head experiment.

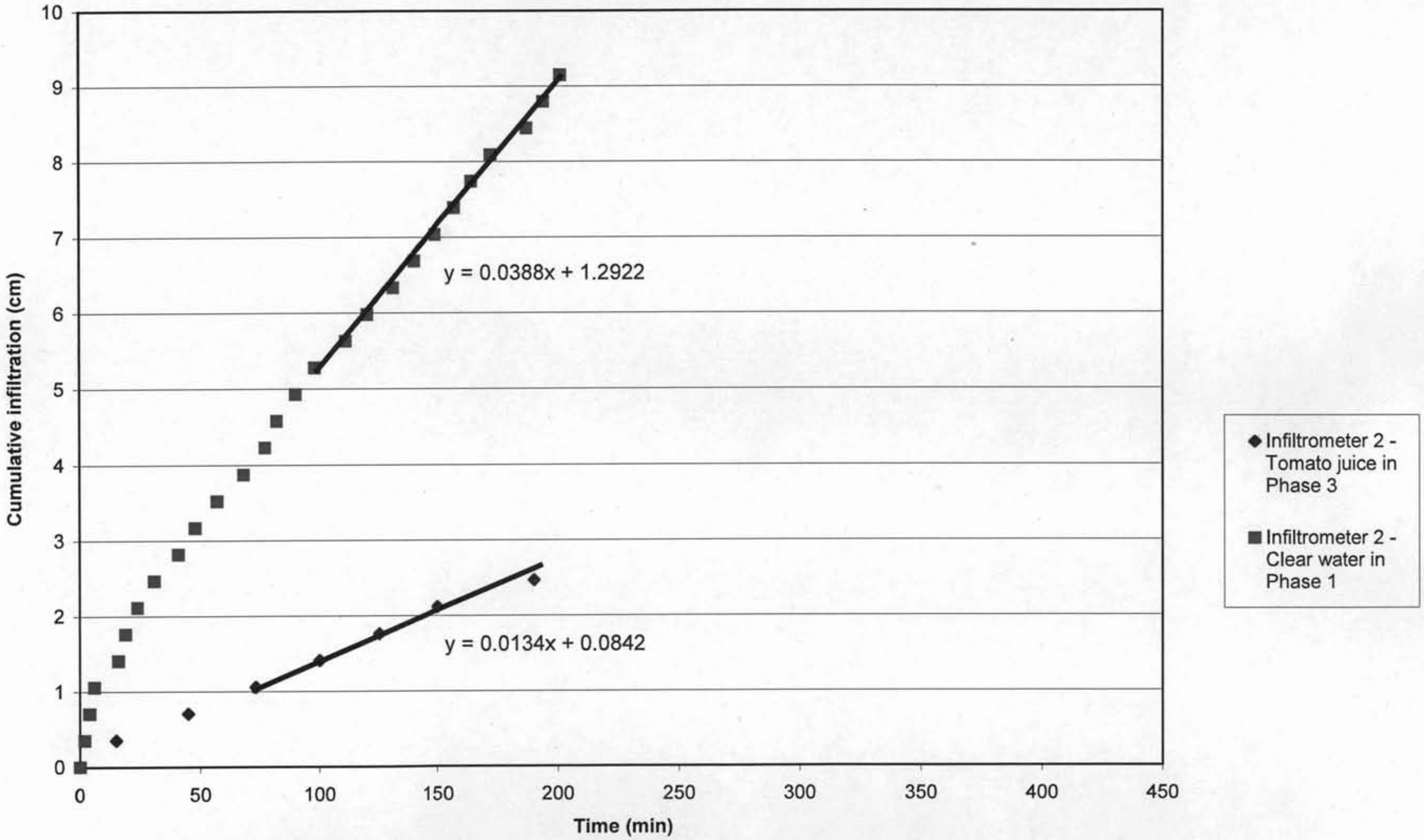


Figure 6. Soil 3 - CSUS sand (SW/SM). Phase 1 and Phase 3 data for Infiltrometer 2. Constant head experiments

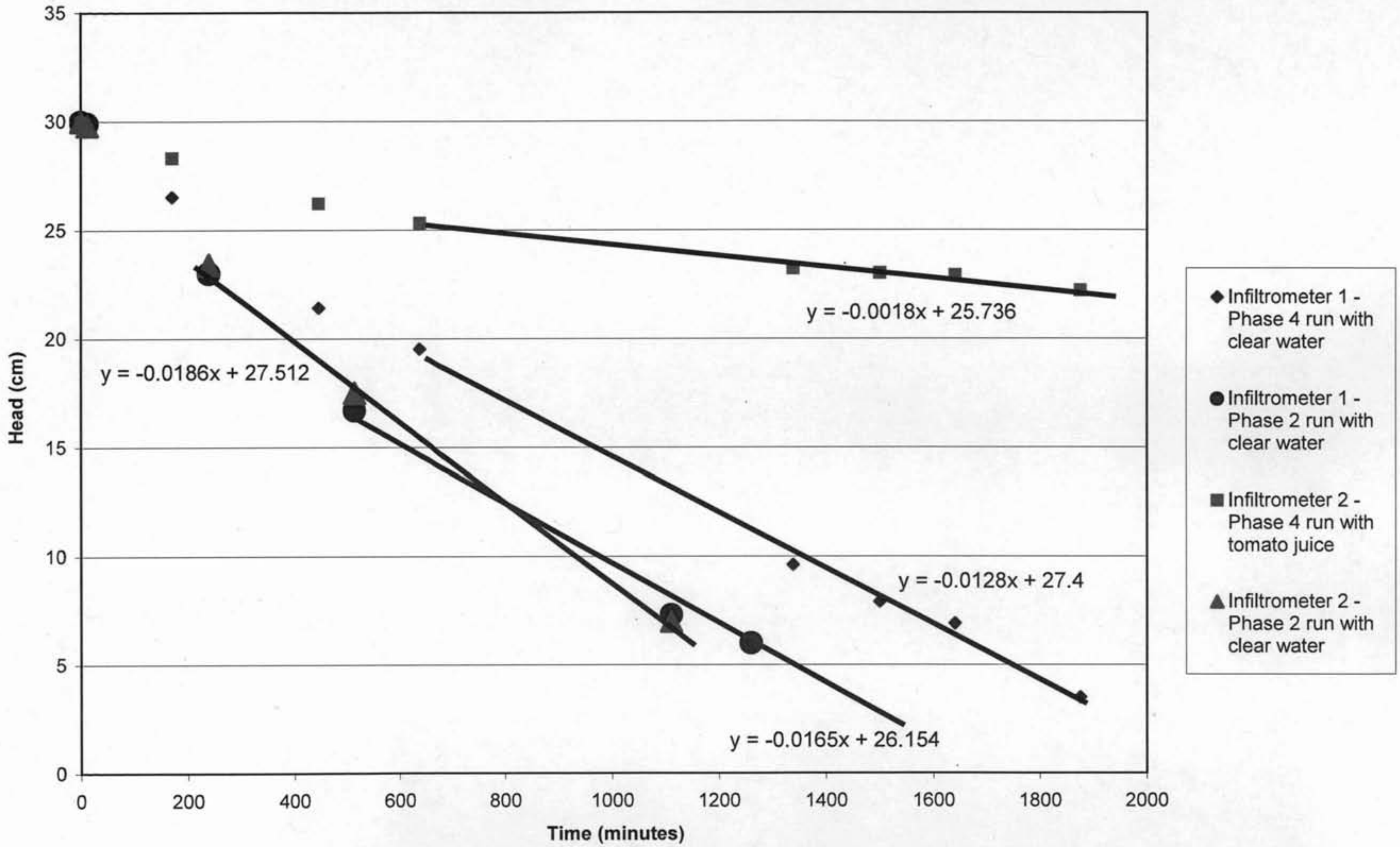


Figure 7. Soil 2 - CSUS sand (SW/SM. Phase 2 and Phase 4 data for Infiltrometers 1 and 2 - Falling head experiment

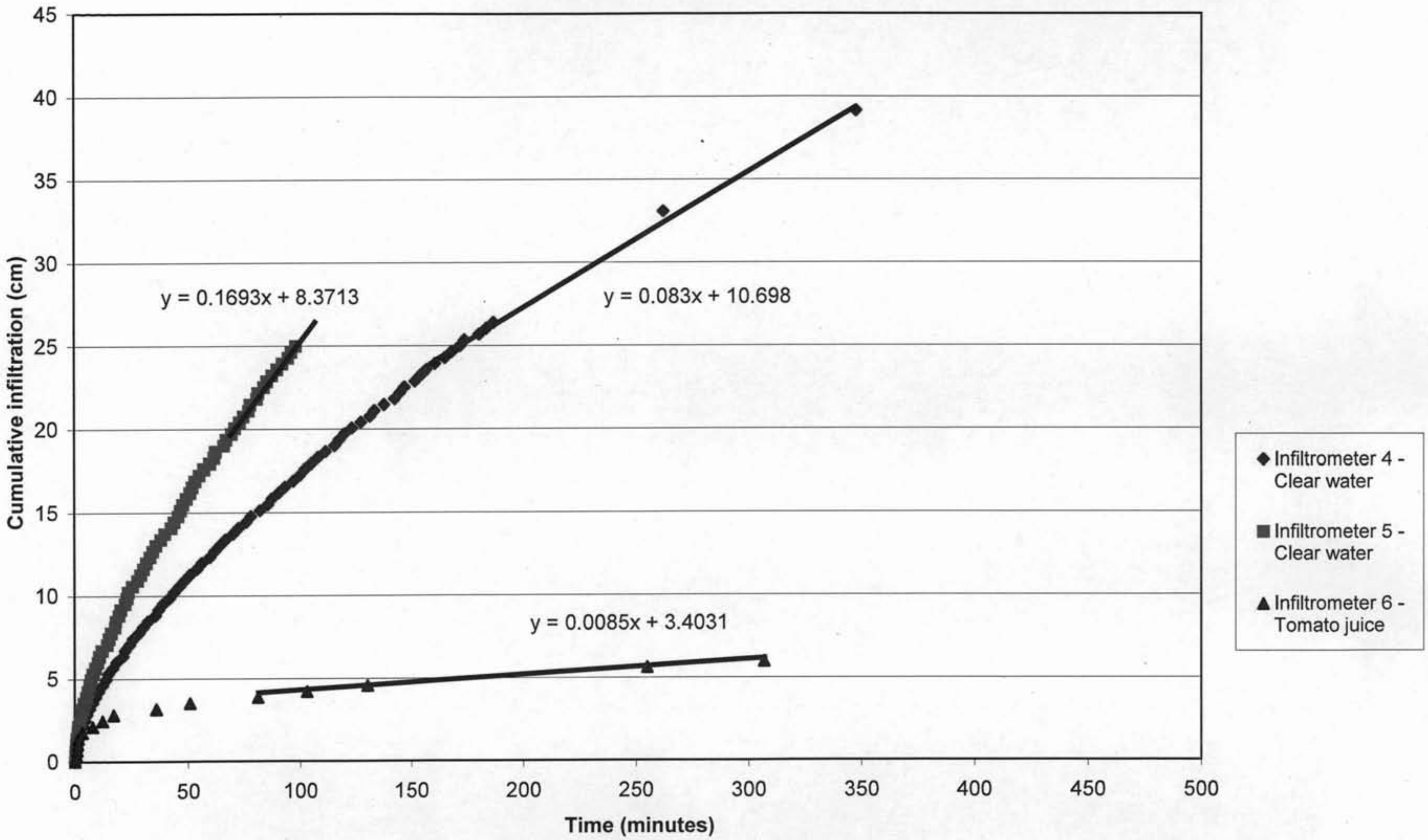


Figure 8. Soil 3 - Merced silty clay (CH). Phase 1 data - Constant head experiment.

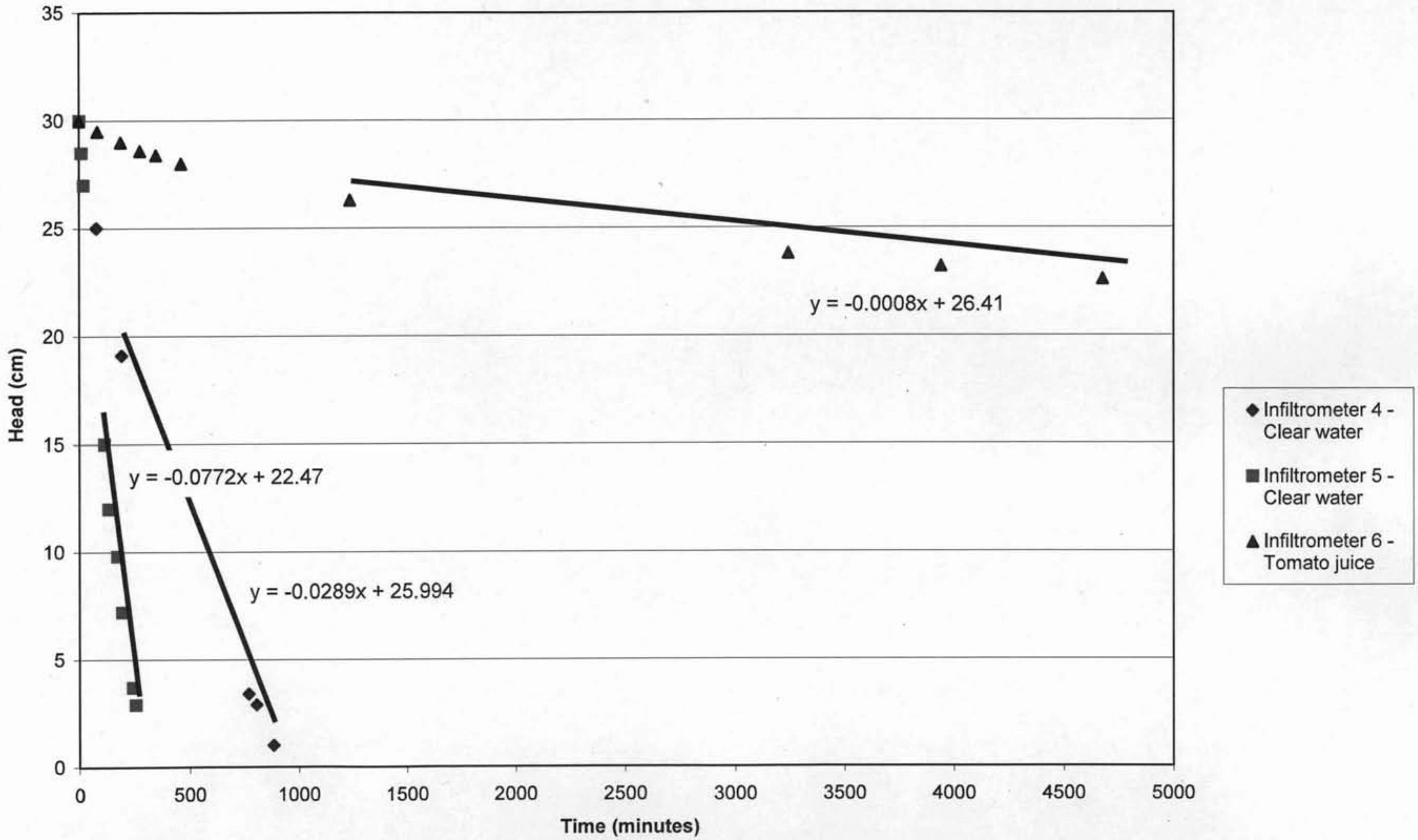


Figure 9. Soil 3 - Merced silty clay (CH). Phase 2 data - Falling head experiment

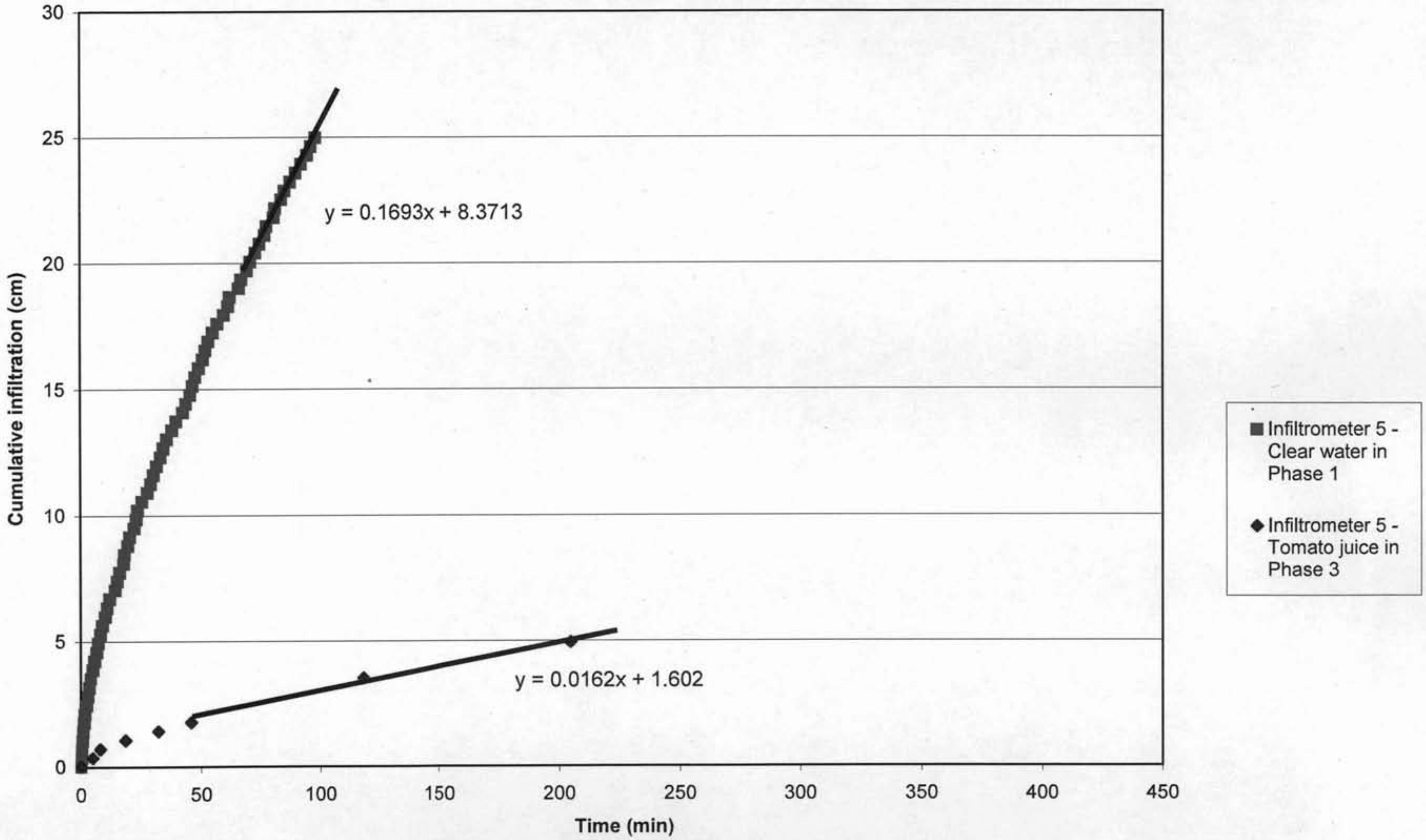


Figure 10. Soil 3 - Merced silty clay (CH). Phase 1 and Phase 3 data for Infiltrometer 5 - Constant head experiment.

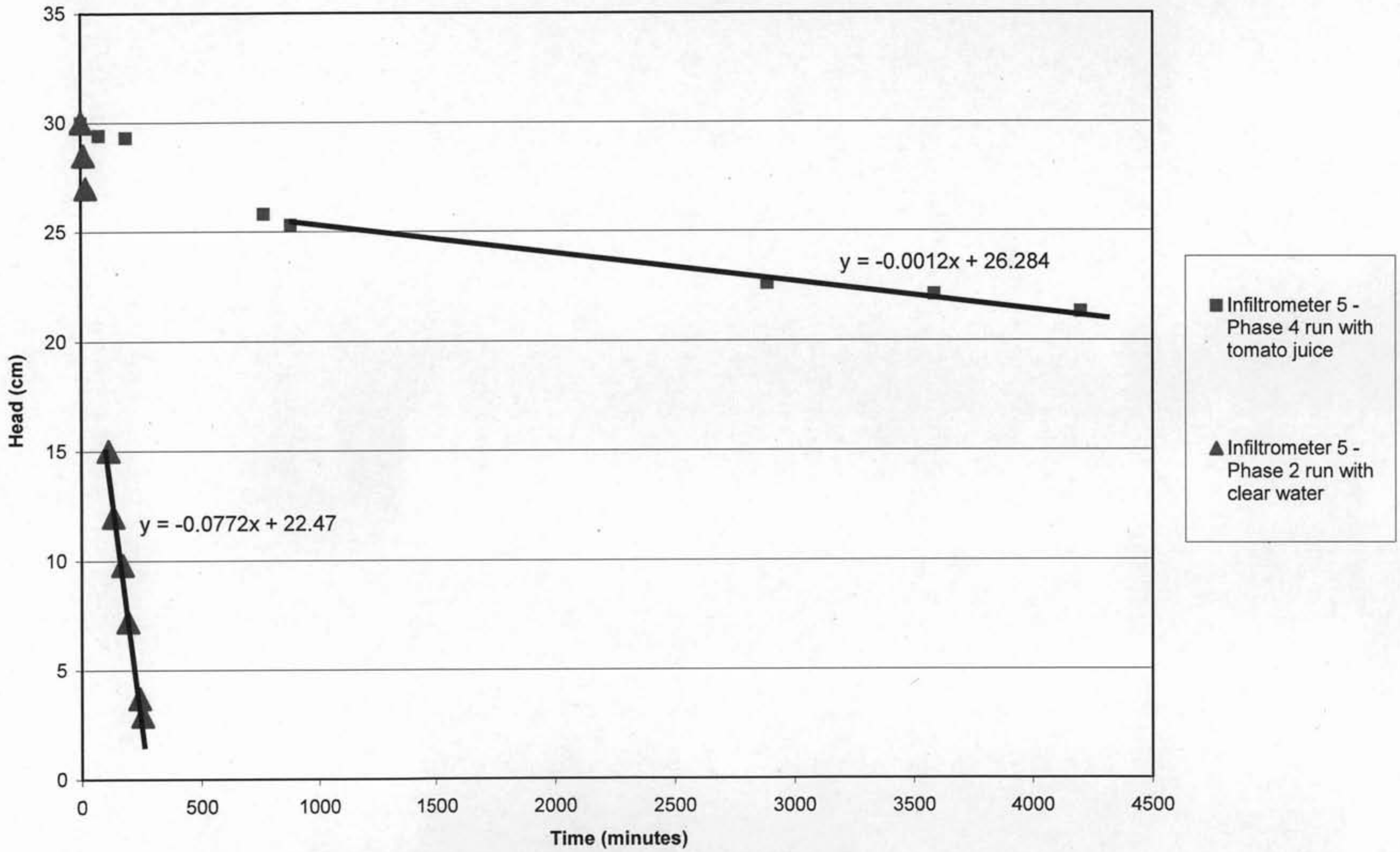


Figure 11. Soil 3 - Merced silty clay (CH). Phase 4 and Phase 2 data for Infiltrometer 5 - Falling head experiment

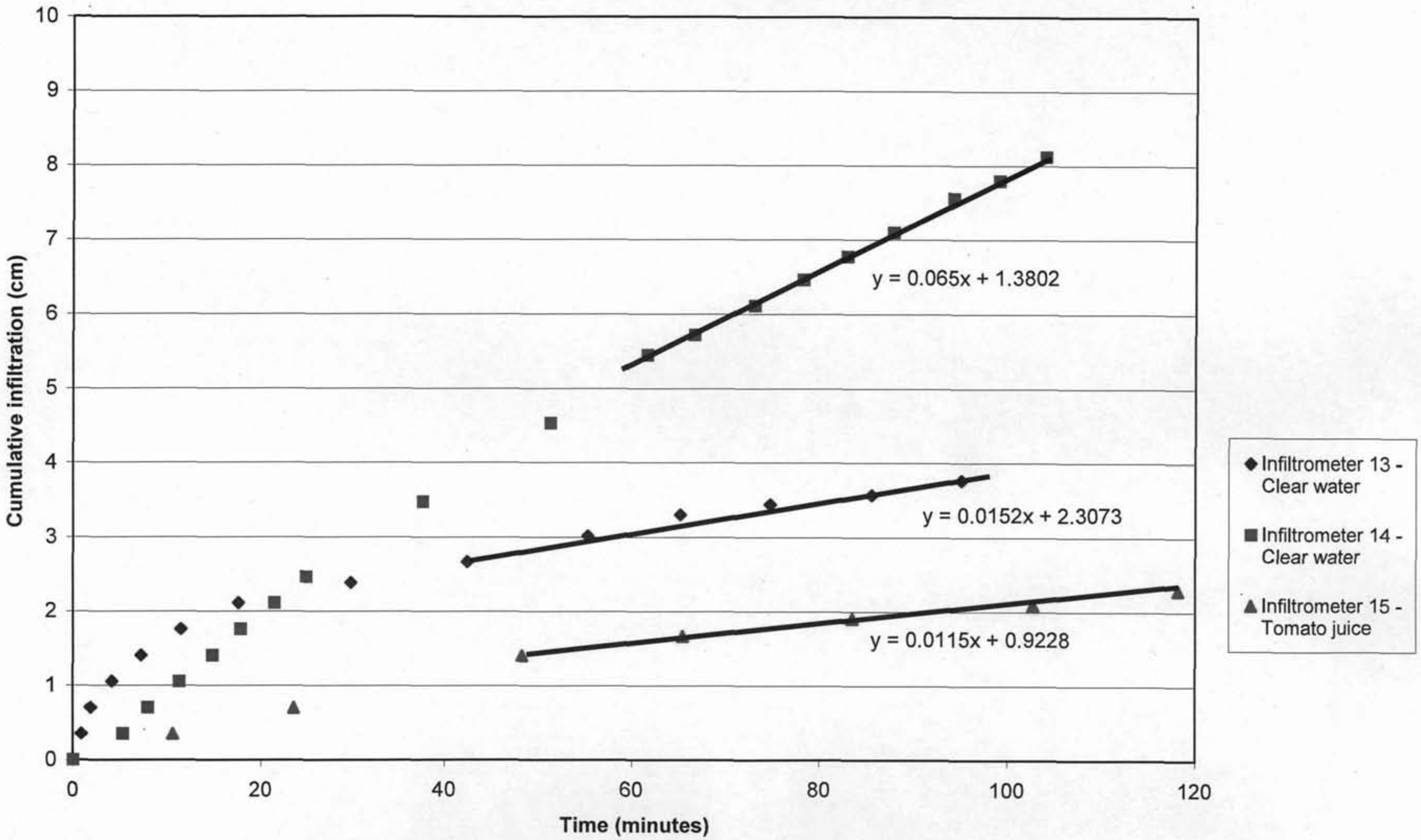


Figure 12. Soil 4 - Oakdale silty clay (CH). Phase 1 data - Constant head experiment.

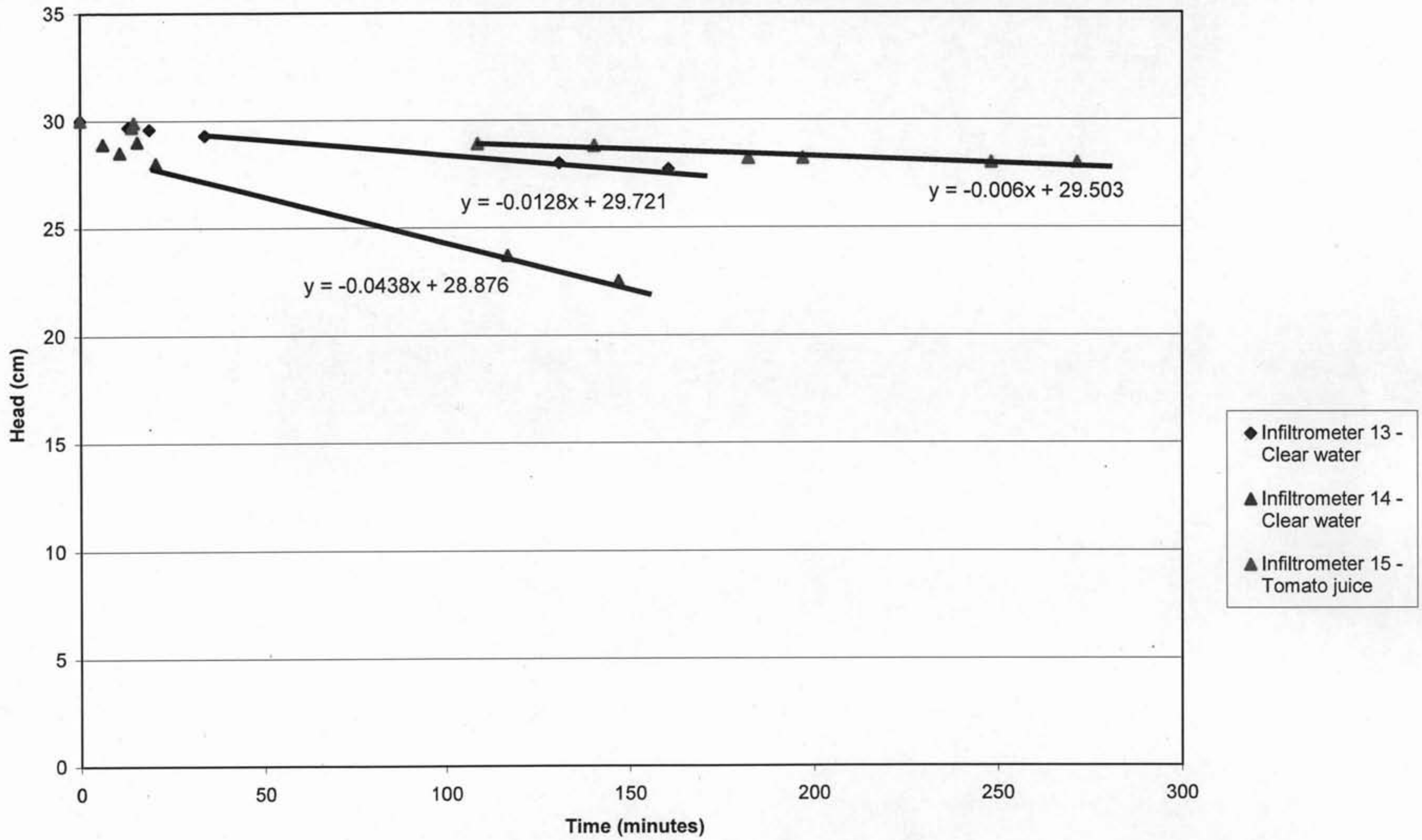


Figure 13. Soil 4 - Oakdale silty clay (CH). Phase 2 data - Falling head experiment.

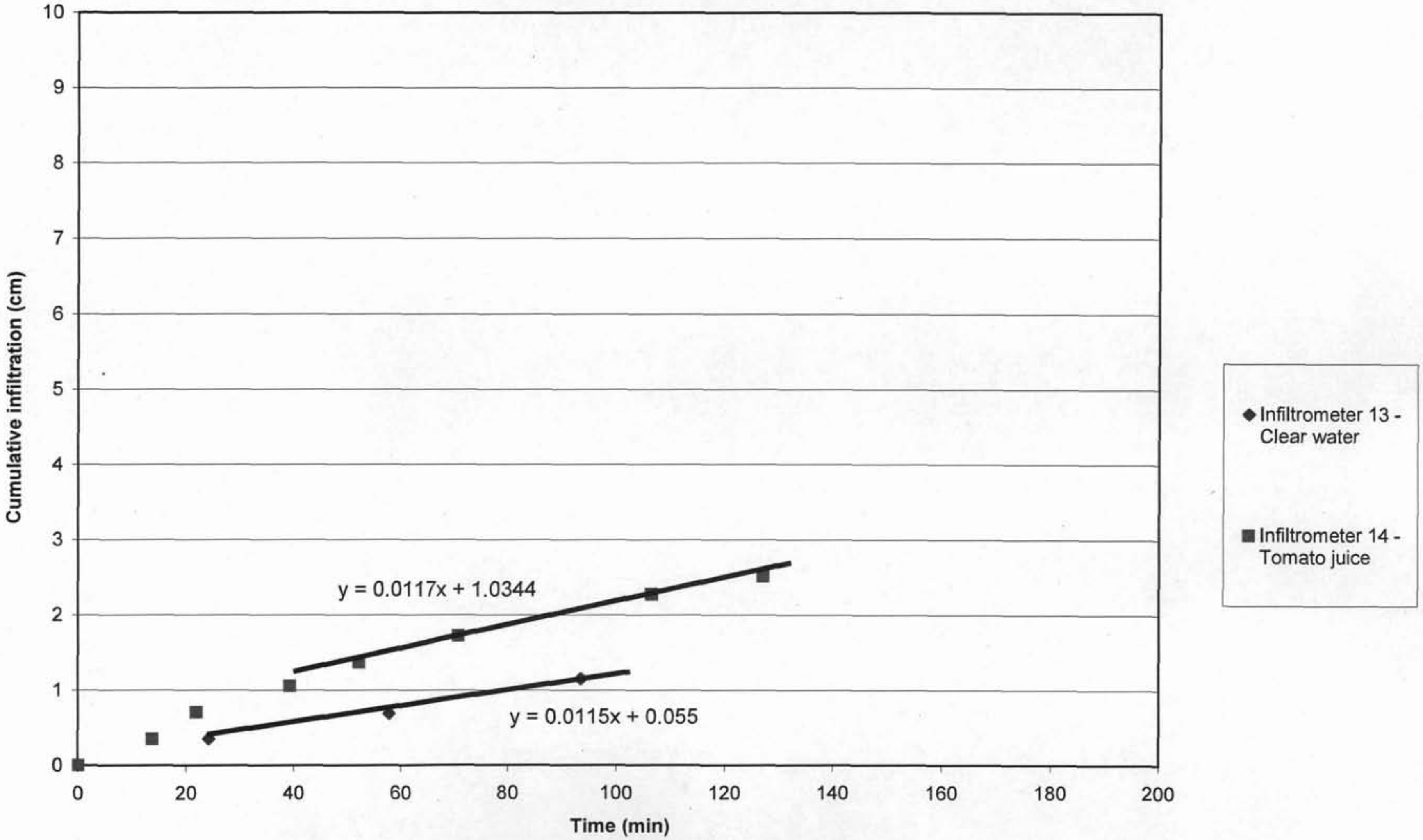


Figure 14. Soil 4 - Oakdale silty clay (CH). Phase 3 data for Infiltrometers 13 and 14 - Constant head experiment

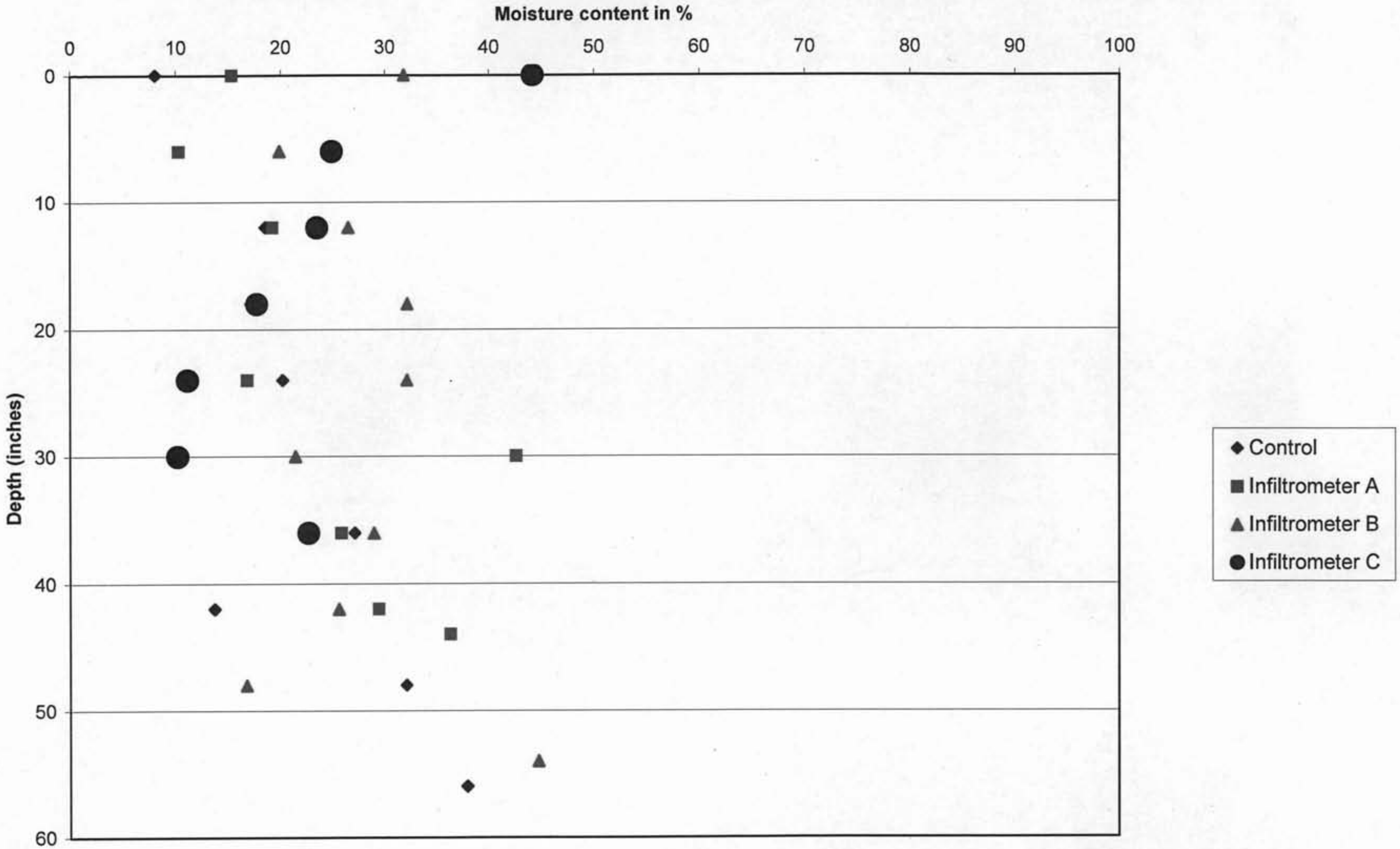


Figure 15. Depth vs. moisture content plots for Ballico sand.

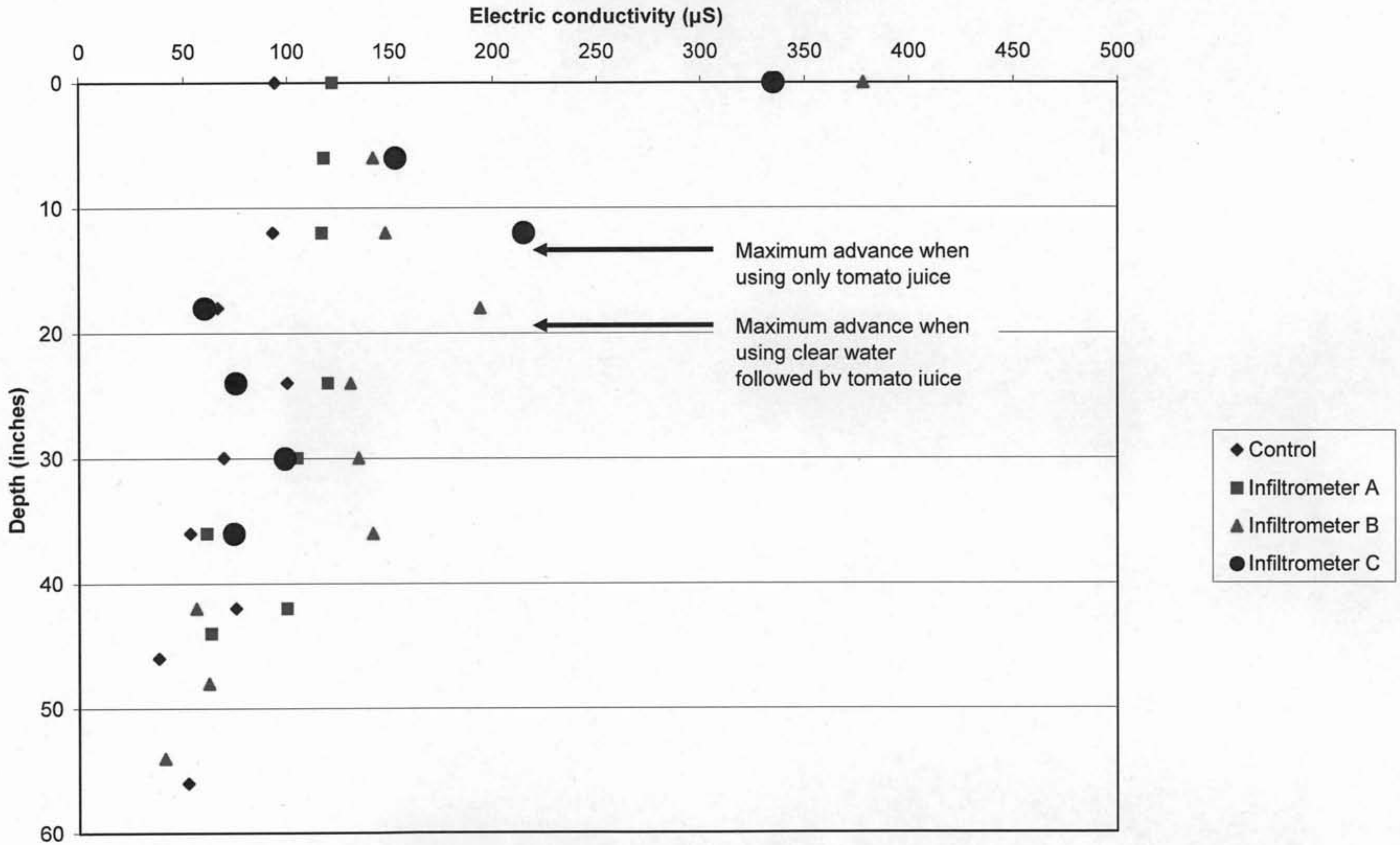


Figure 16. Depth vs. electric conductivity plots for Ballico sand.

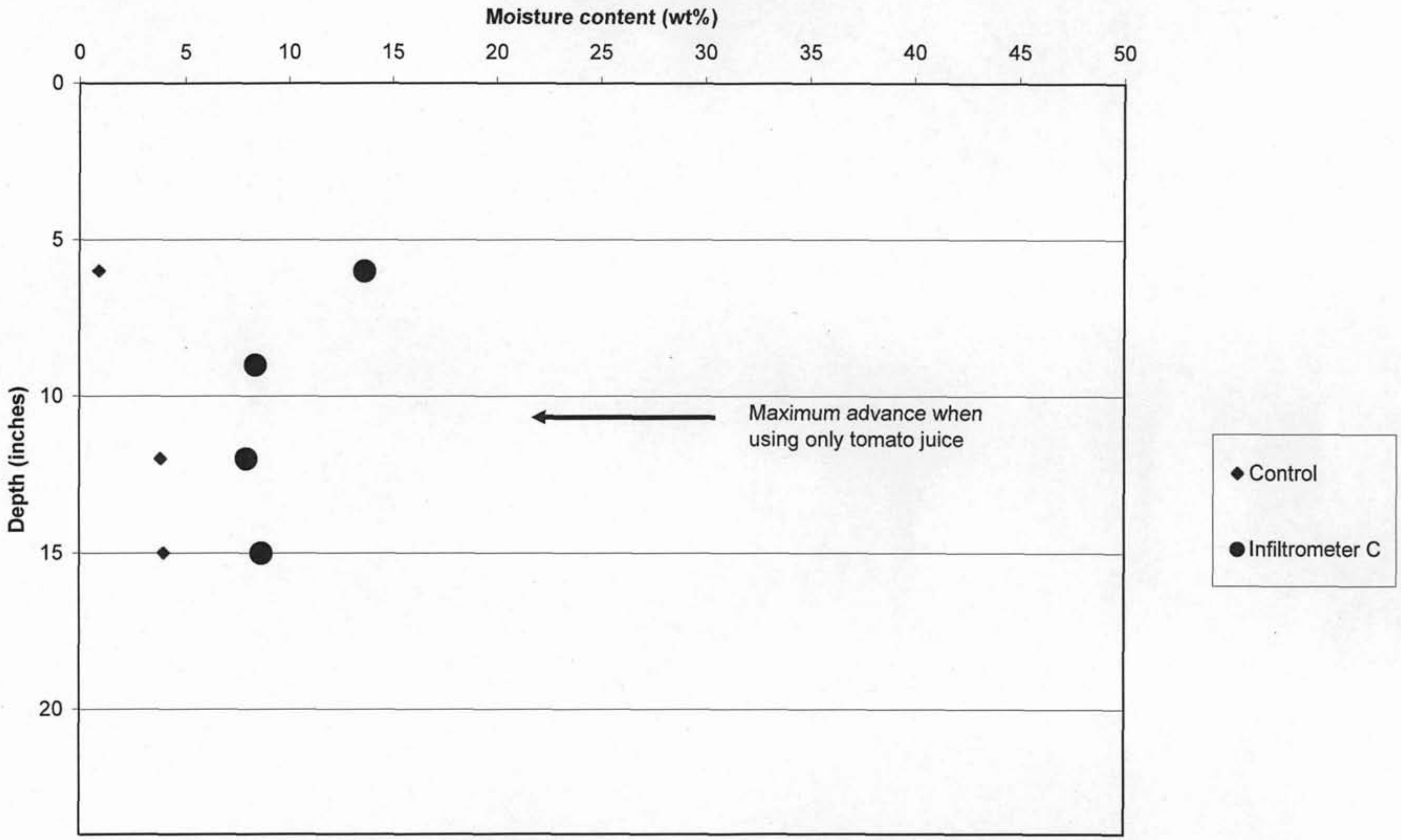


Figure 17. Depth vs. moisture content plots for CSUS sand.

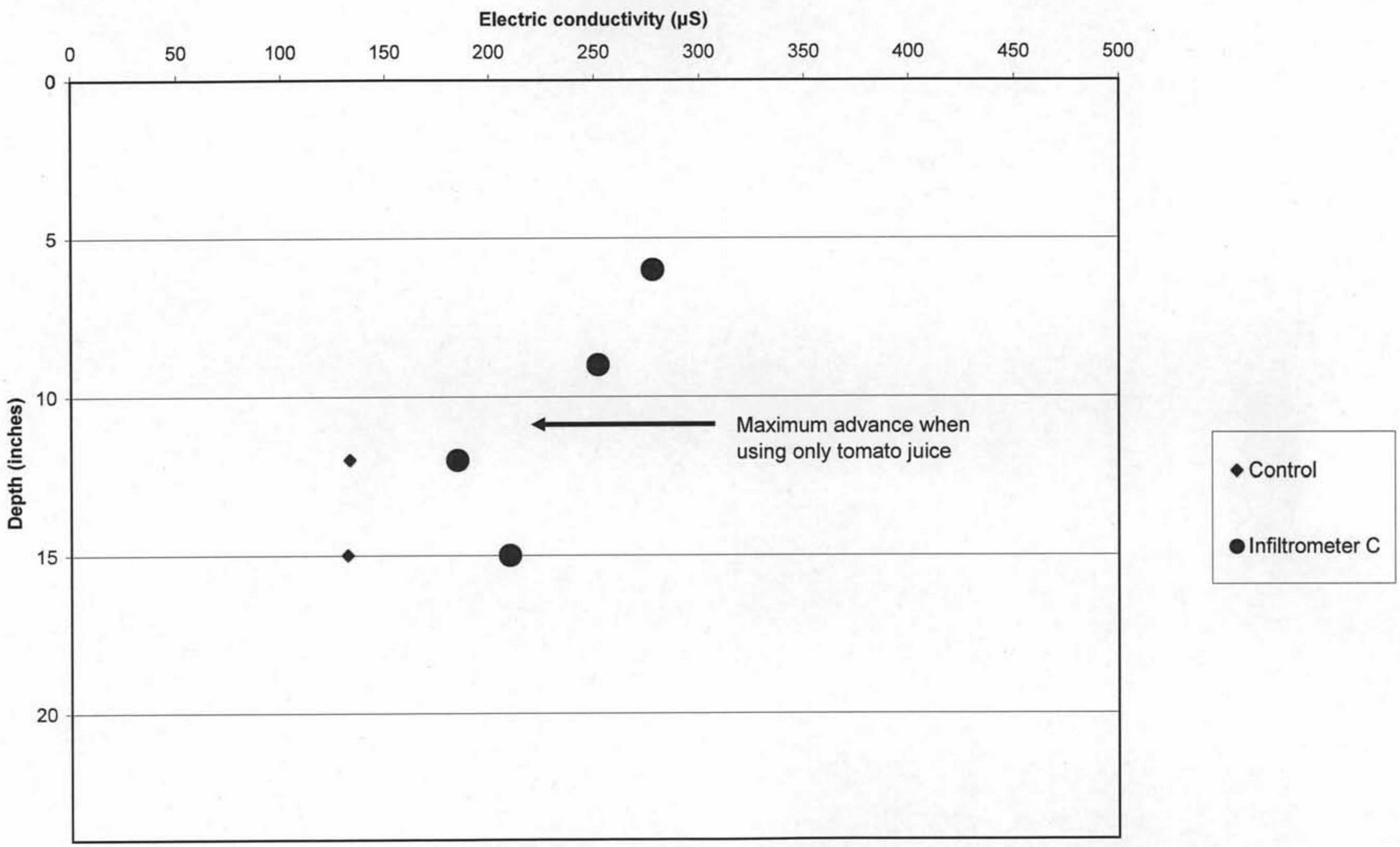


Figure 18. Depth vs. electric conductivity plots for CSUS sand.

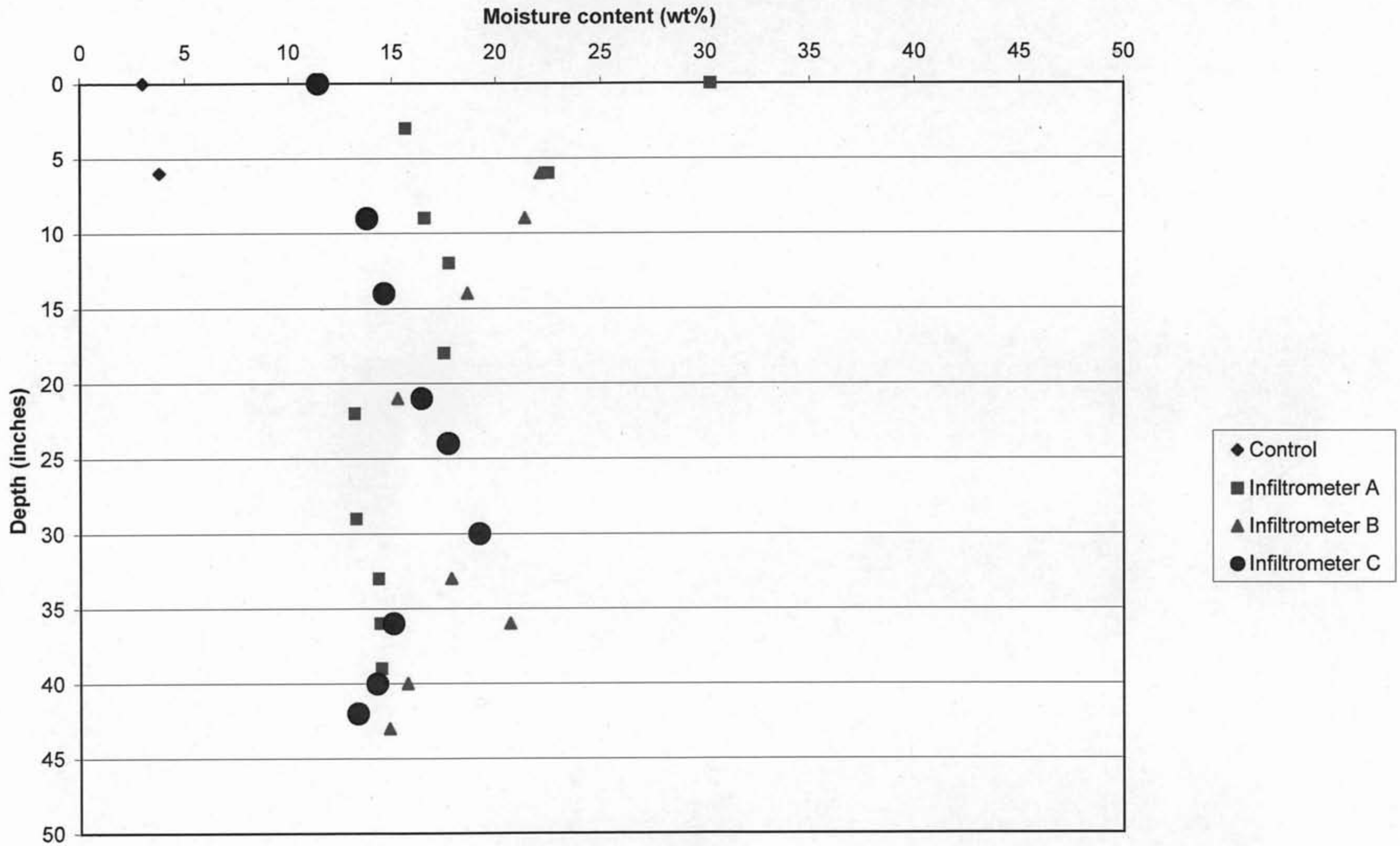


Figure 19. Depth vs. moisture content plots for Merced clay.

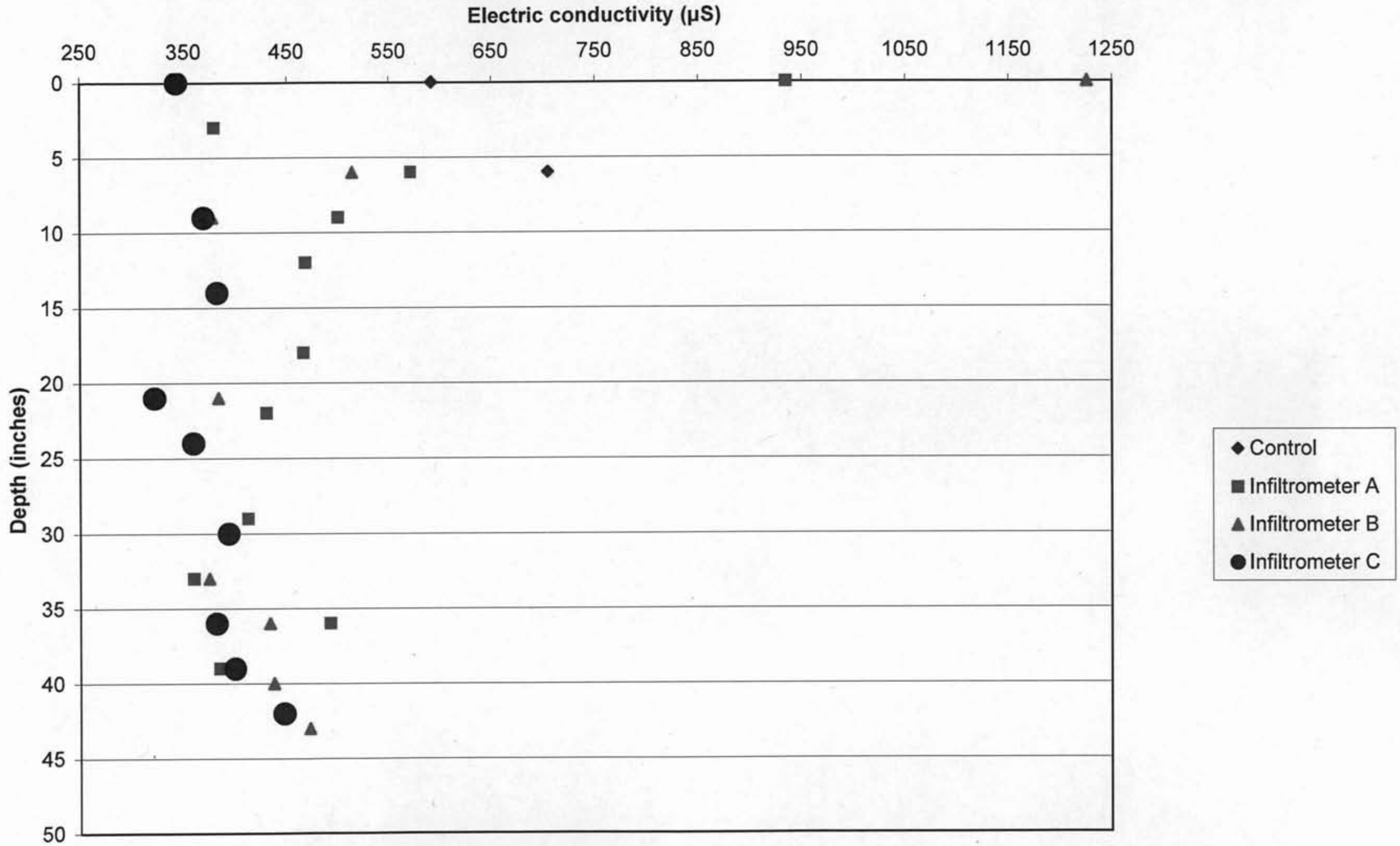


Figure 20. Depth vs. electric conductivity plots for Merced clay.

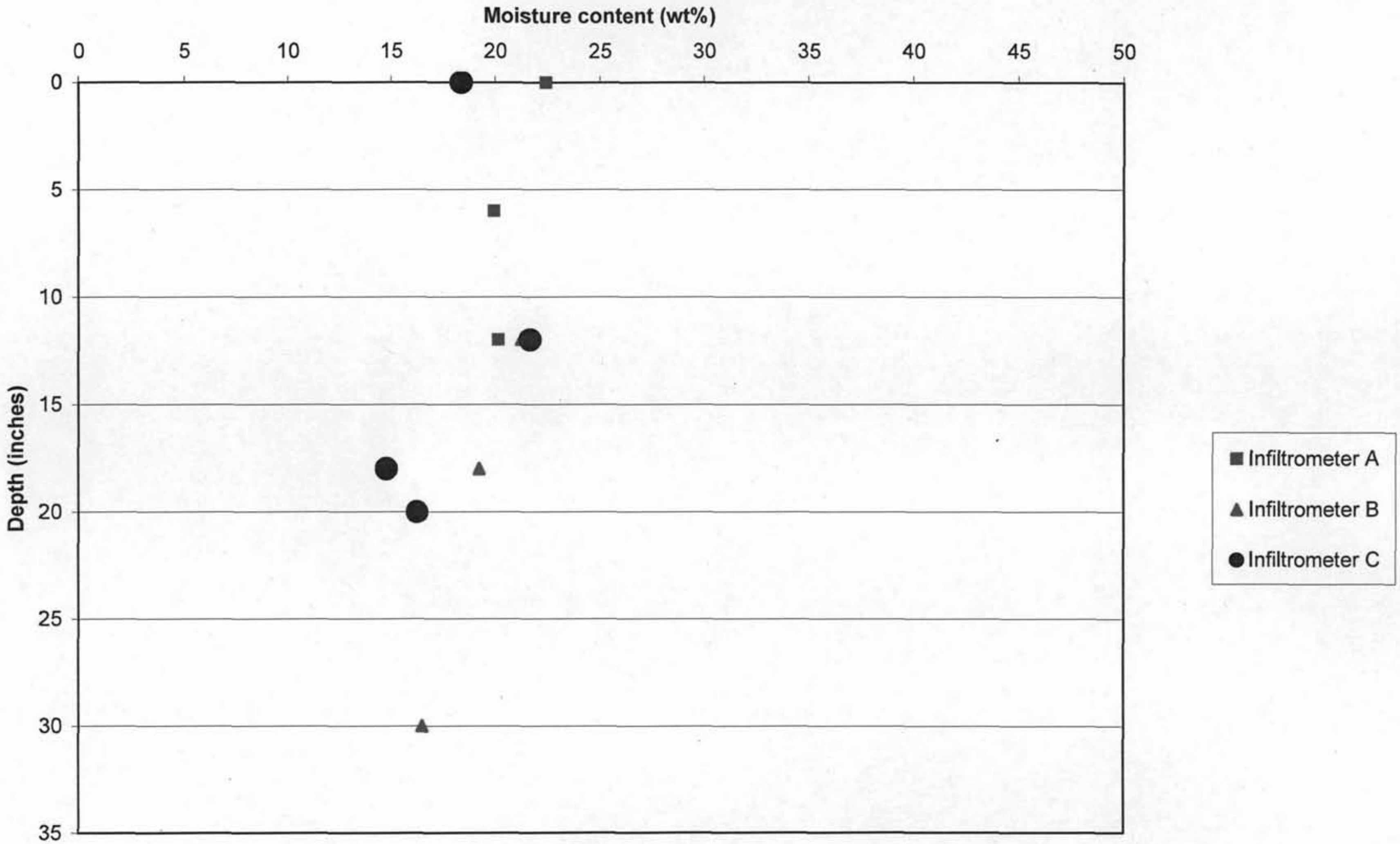


Figure 21. Depth vs. moisture content plots for Oakdale clay.

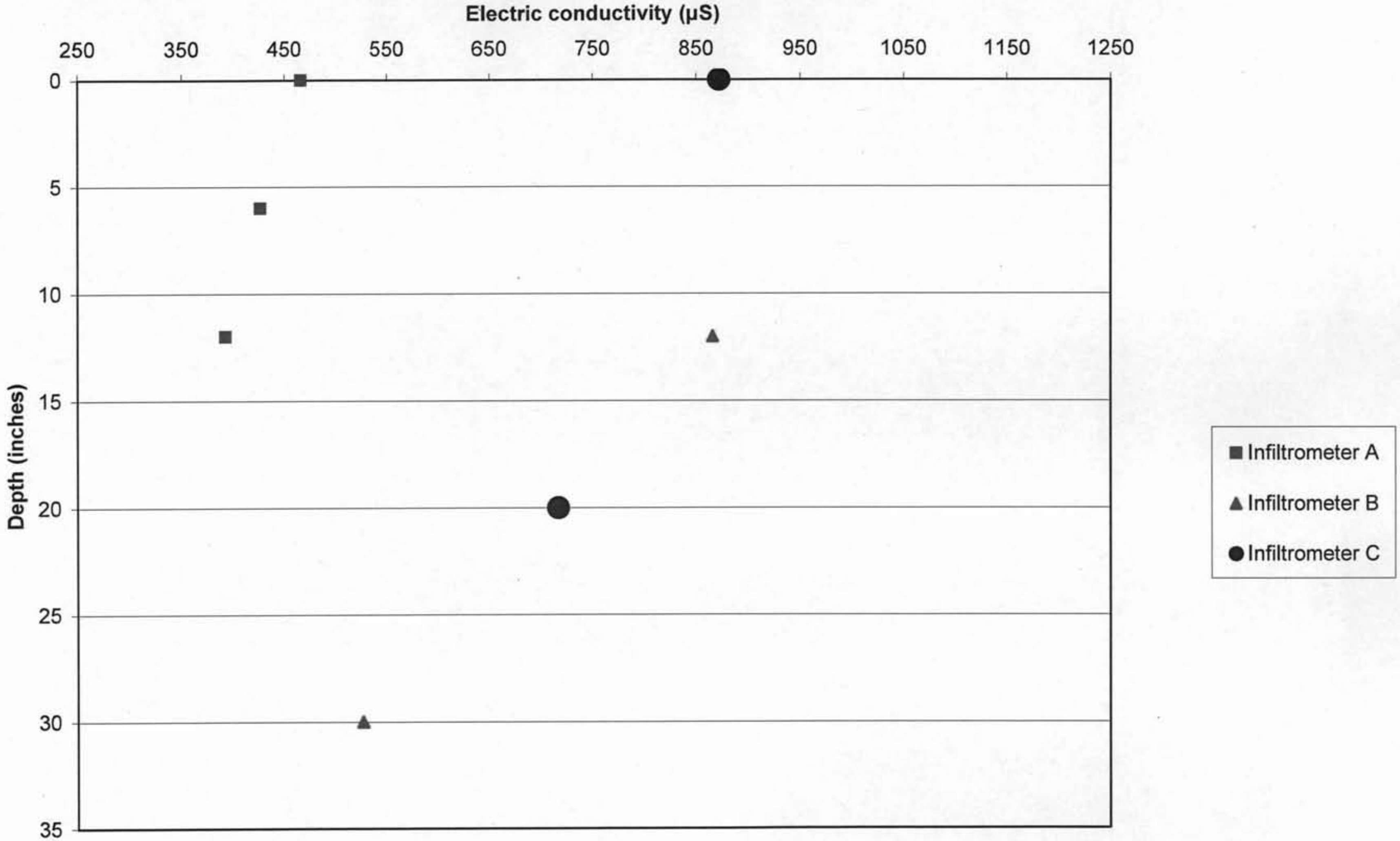


Figure 22. Depth vs. electric conductivity plots for Oakdale clay.

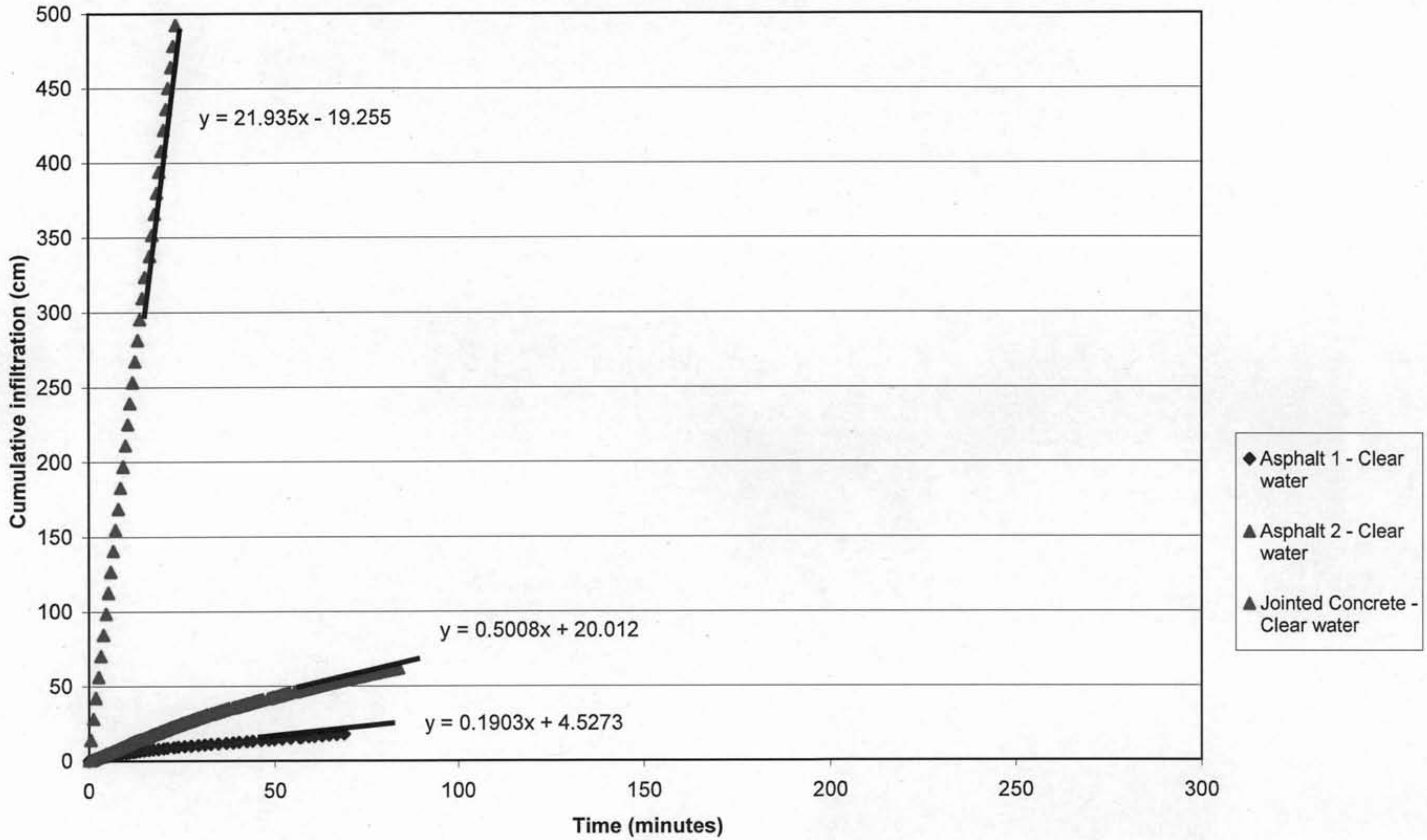


Figure 23. Phase 1 data - constant head experiments with clear water.

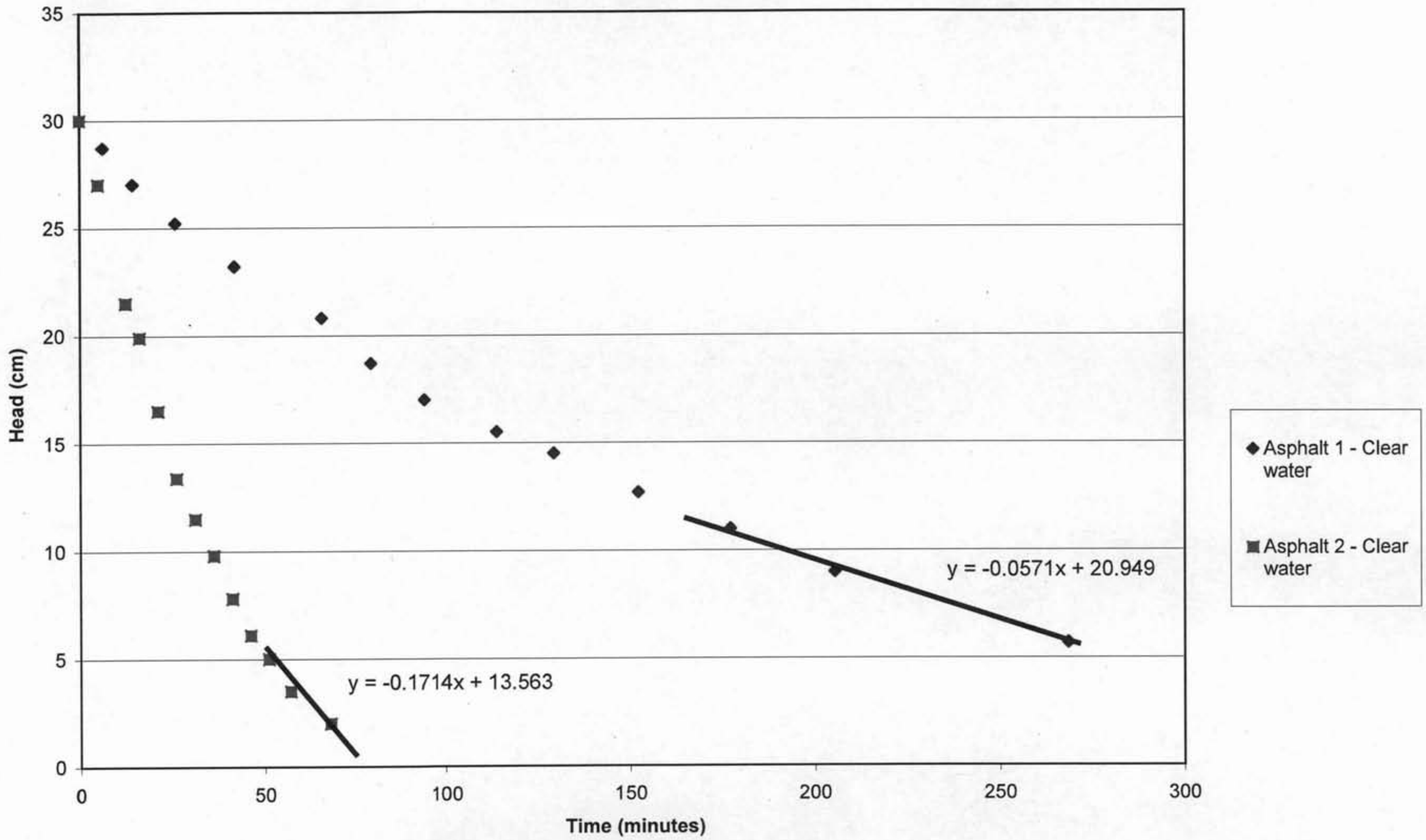


Figure 24. Phase 2 data - Falling head experiments.

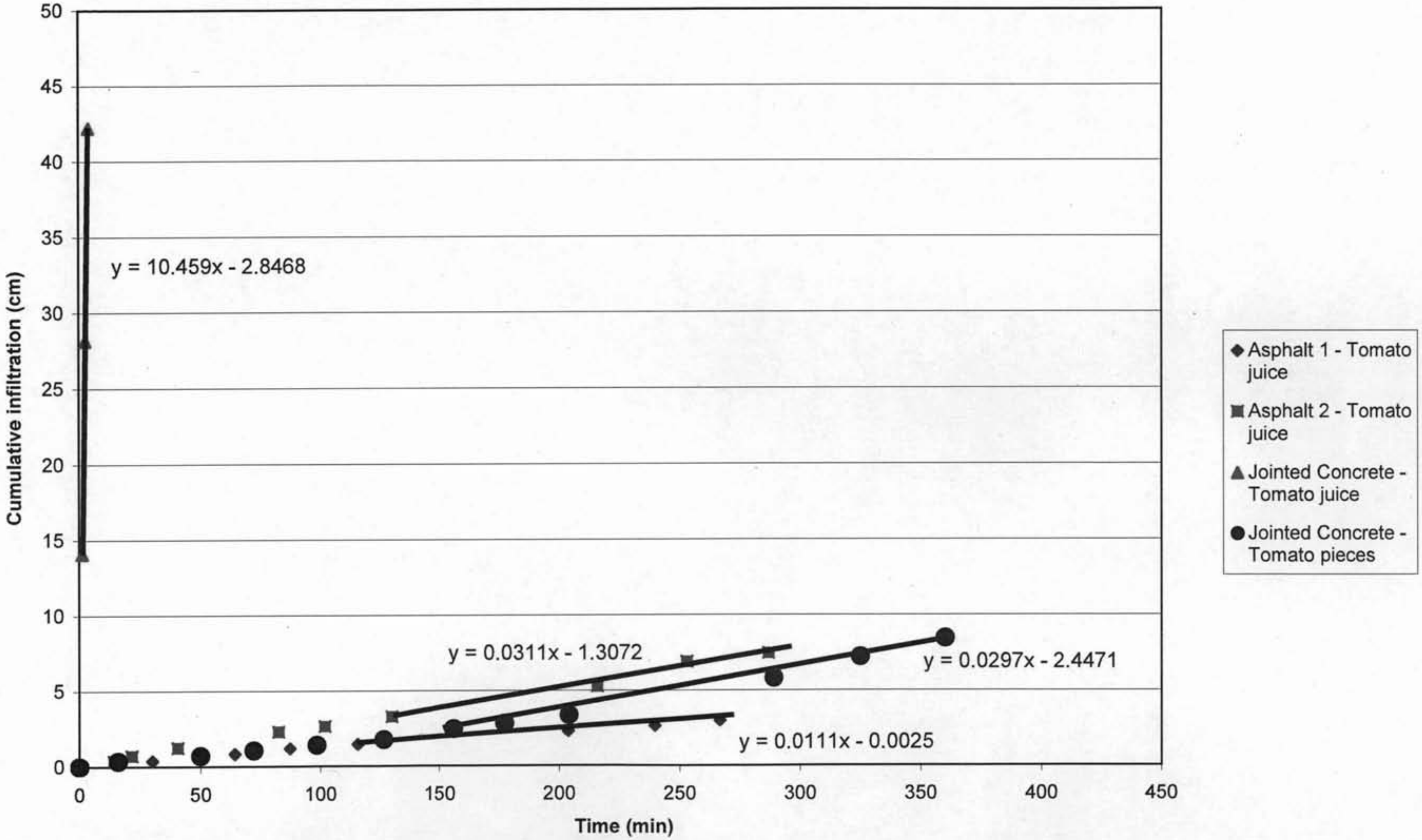


Figure 25. Phase 3 data - constant head experiments with tomato juice or tomato pieces.

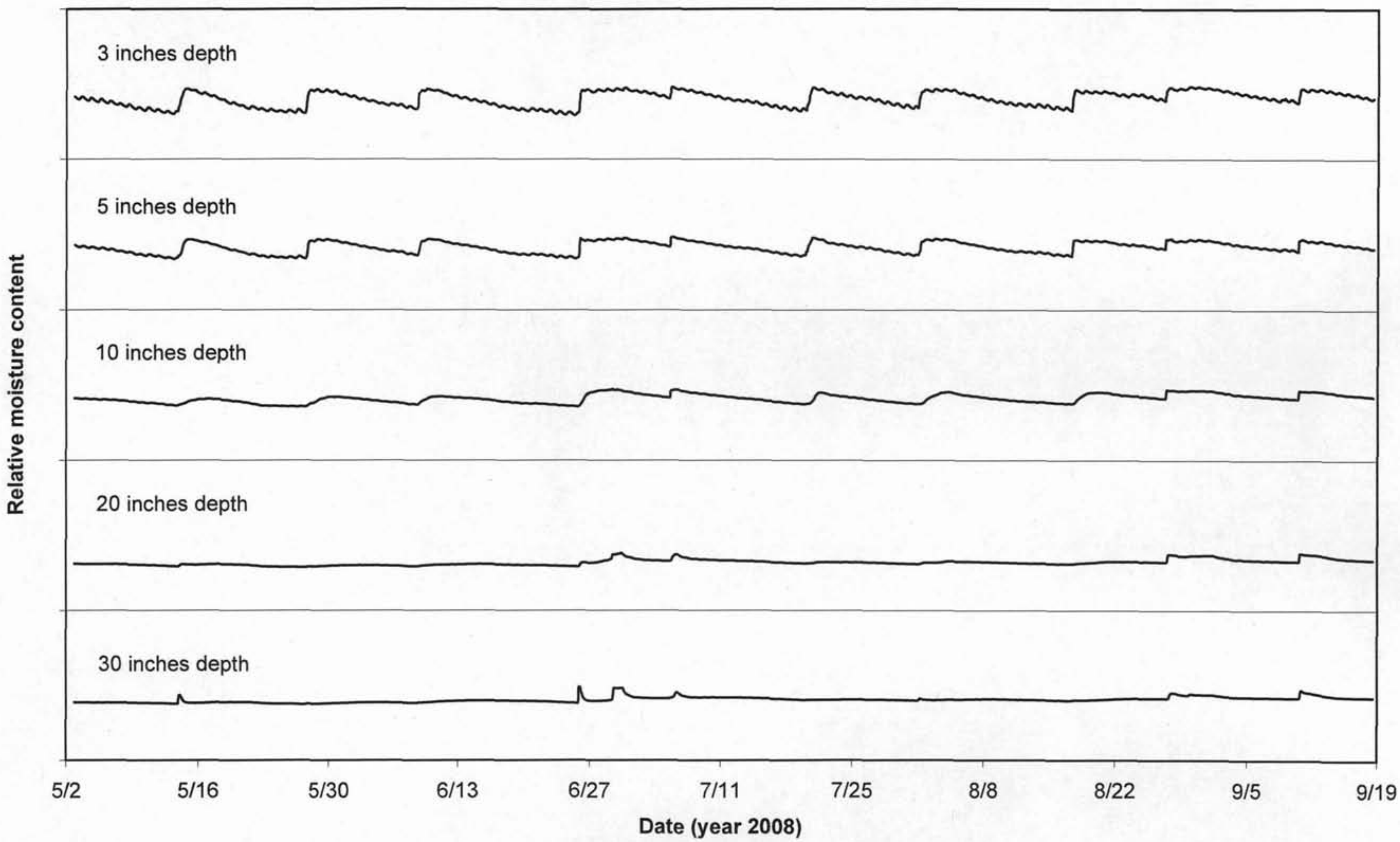


Figure 26. Soil moisture at Mapes Ranch. Each graph has a scale from 0 to 1.

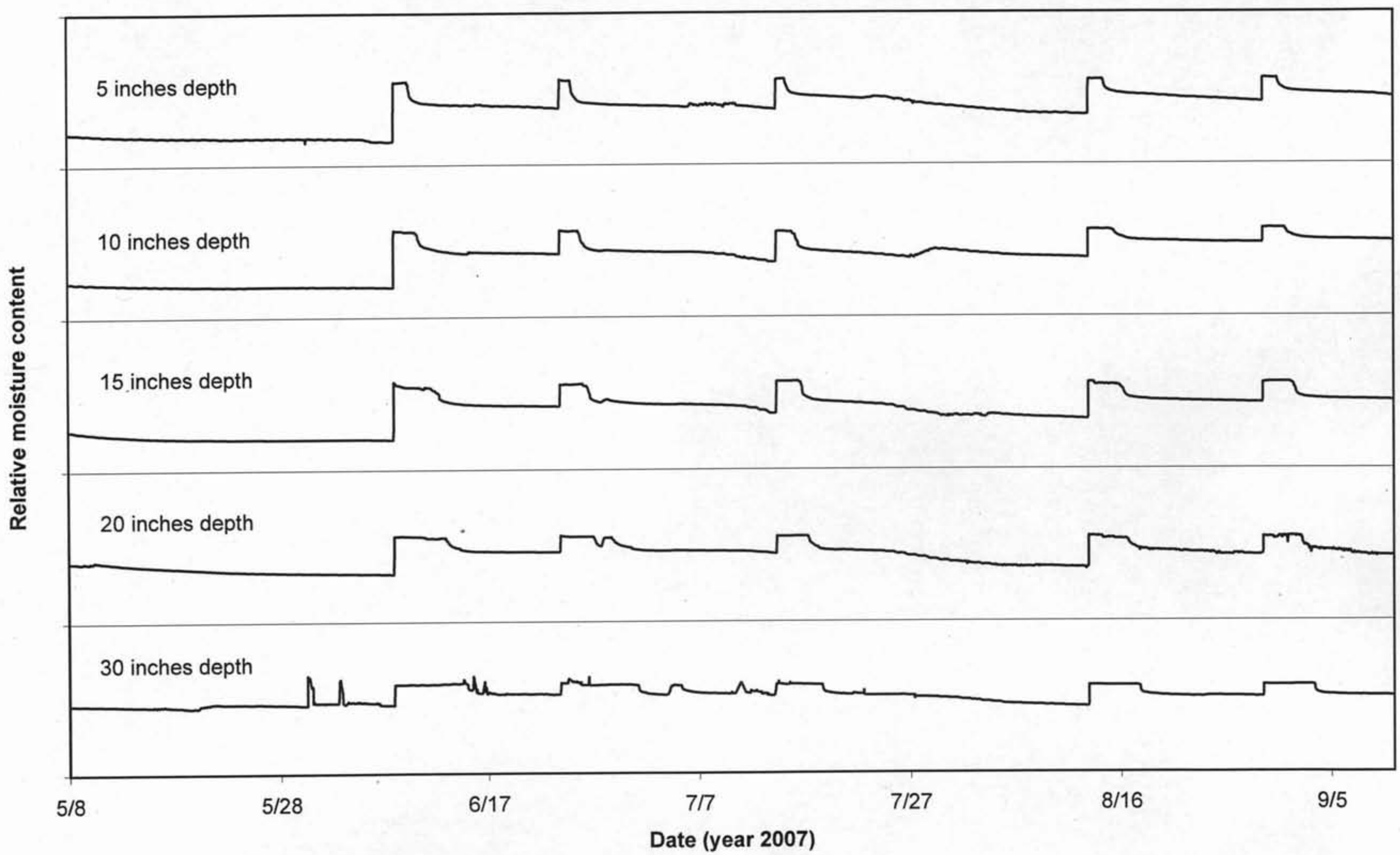


Figure 27. Soil moisture at Dos Rios Ranch. Each graph has a scale from 0 to 1.

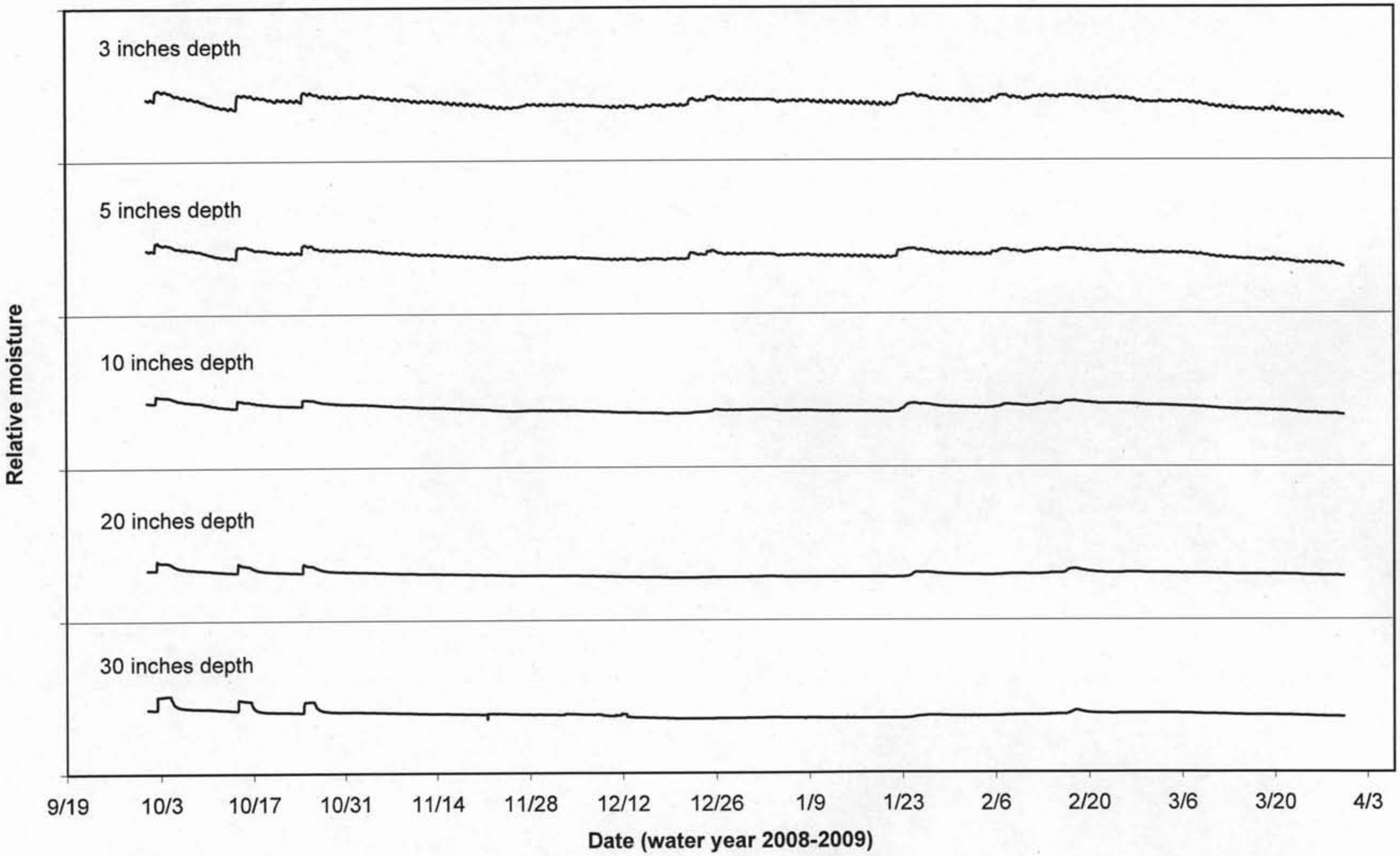


Figure 28. Soil moisture at Mapes Ranch. Each graph has a scale from 0 to 1.

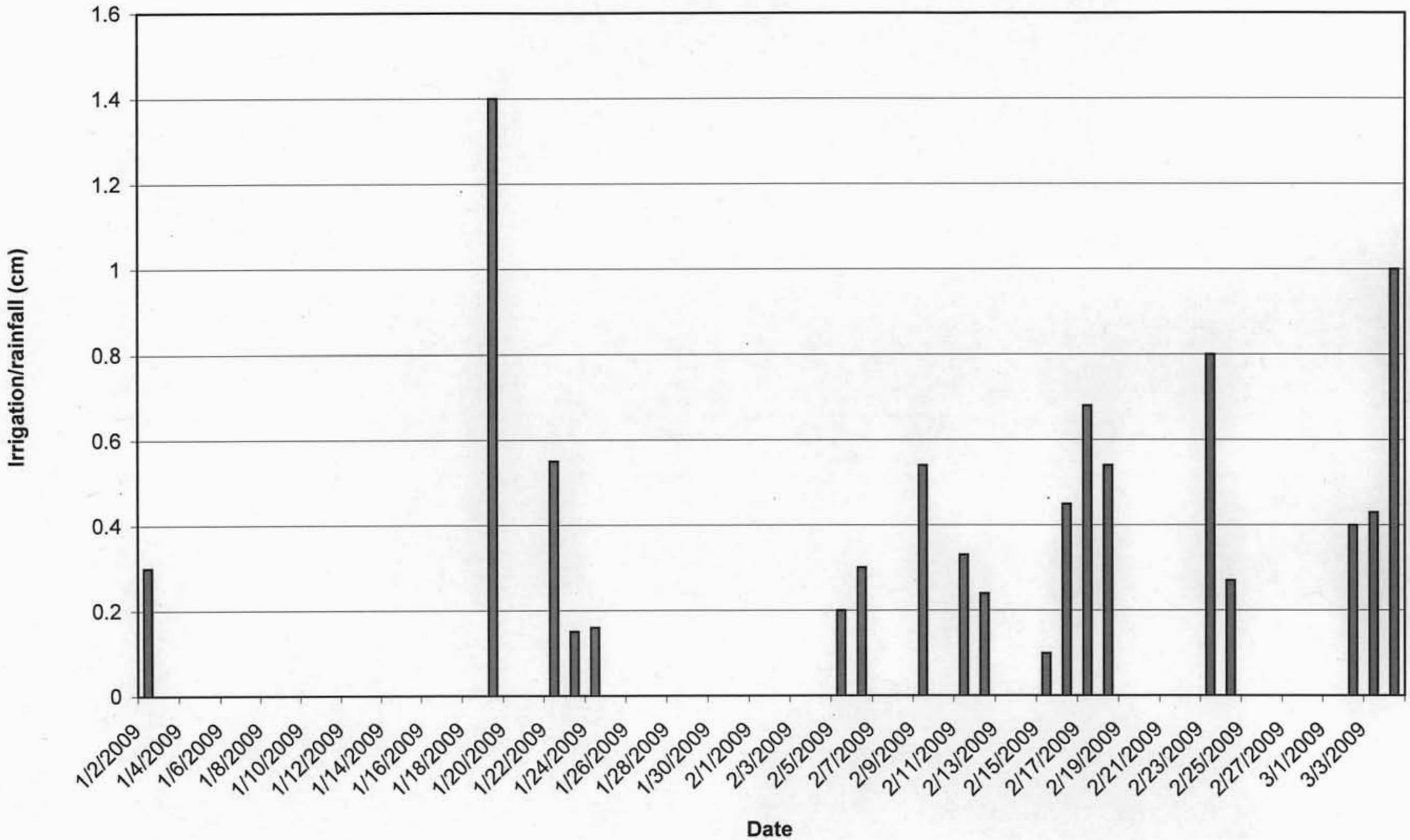


Figure 29. Depth of irrigation or rainfall on lysimeters.

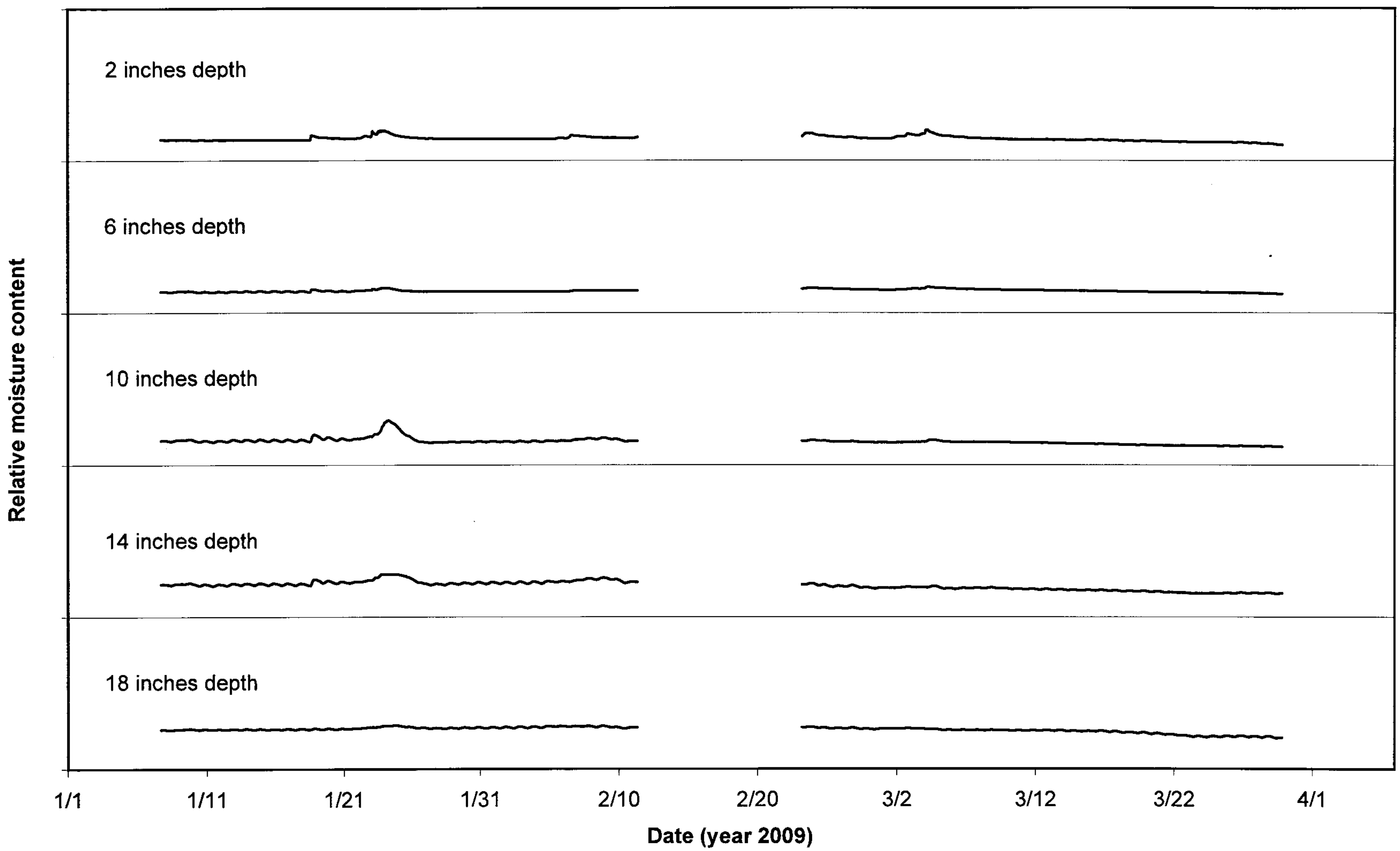


Figure 30. Soil moisture in the CSUS sand lysimeter. Each graph has a scale from 0 to 1.

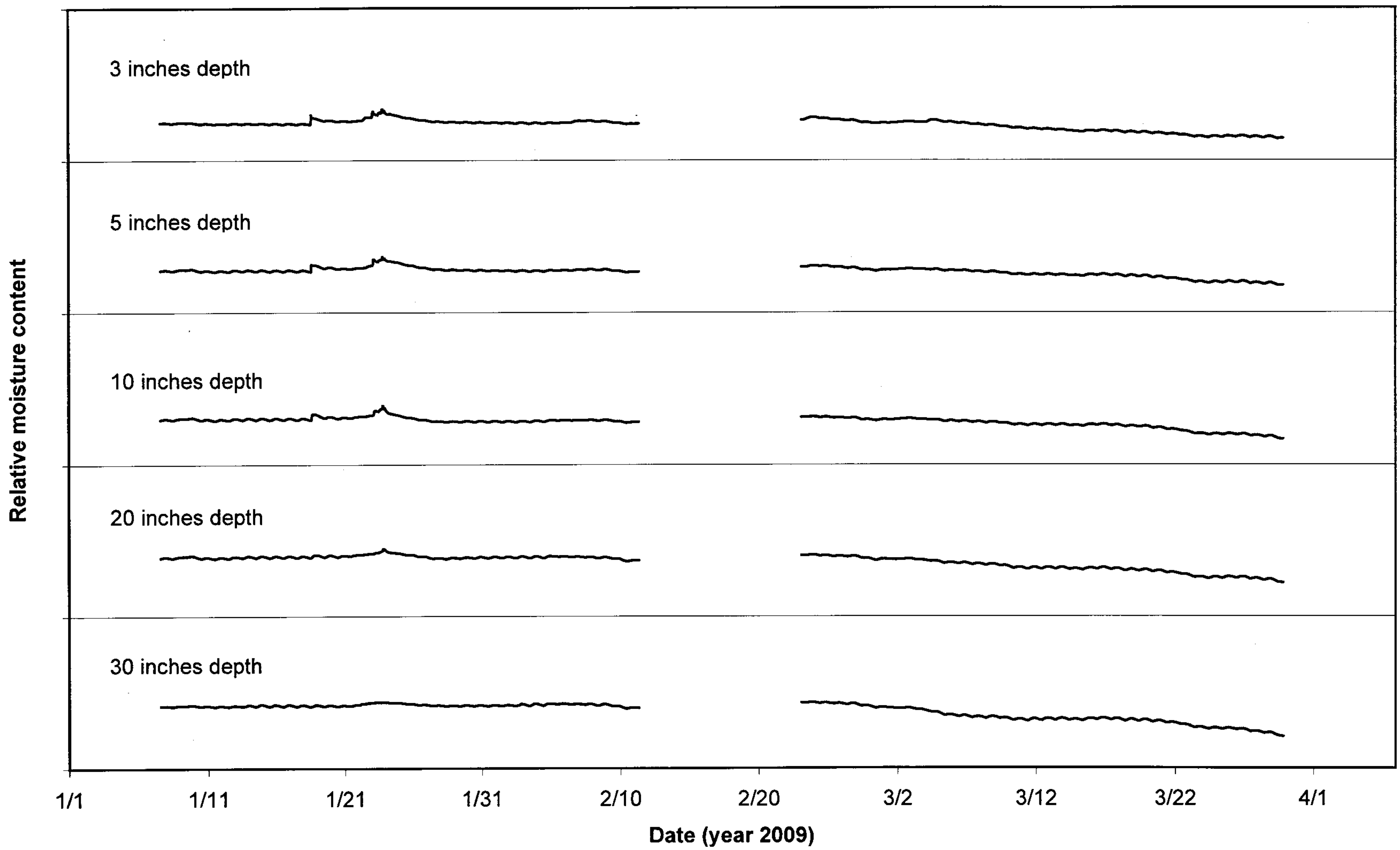


Figure 31. Soil moisture in the Oakland clay lysimeter. Each graph has a scale from 0 to 1.

APPENDIX 1

CHEMICAL ANALYSES OF VEGETABLE AND FRUIT SLURRY SAMPLES

Report of Water Analysis

DELLAVALLE Laboratory, Inc.
Chemists and Consultants
1910 W. McKinley, Suite 110, Fresno, CA 93728
FAX (559) 268-8174 - (800) 228-9896 - (559) 233-6129

CSU Fresno Foundation
4910 N Chestnut
Fresno CA 93726-1852
16731
01

Material Submitted: Water

Lab No. 124767
Sample Date
Sample Time
Submitted Date 12/16/2008
Submitted by Ferriz/Mint
Reported Date 1/23/2009
Location/Project Food Processing Byproducts
Copy To hferriz@geology.csustan.edu
Fax (559) 278-4849
e-mail spasakdee@csufresno.edu

	TDS mg/L	IDS mg/L
MCL—>	500	
MDL—>	10	10
RL—>	10	10
SM—>	2540 C	2540 E
EPA—>		
Analysis Date:	*1/15/2009*	*1/15/2009*
001 CSUS-100-FPB Fruit Puree	66700	1367
002 CSUS-101-FPB Tomato 1 Puree	11600	4600
003 CSUS-102-FPB Tomato 2 Puree	18600	8000

*See external laboratory documentation
MCL = Maximum Contaminant Level according to the California Domestic Water Quality and Monitoring Regulations (Title 22)
MDL = Method Detection Limit; **RL** = Reporting Limit
SM = Standard Methods for the Examination of Water and Wastewater, 19th ed., 1995
EPA = Environmental Protection Agency methods used unless otherwise indicated.
Dissolved metals (**bolded**) were filtered.
MBAS molecular weight = 340 grams.
QA/QC available upon request.

Approved By: ______________________
ELAP Certification #1595

DELLAVALLE Laboratory, Inc.
Chemists and Consultants

Report of Water Analysis

1910 W. McKinley, Suite 110, Fresno, CA 93728
FAX (559) 268-8174 - (800) 228-9896 - (559) 233-6129

CSU Fresno Foundation
4910 N Chestnut
Fresno CA 93726-1852
16731
50

Material Submitted: Water

Lab No. 124611
Sample Date
Sample Time
Submitted Date 12/10/2008
Submitted by Horacio Ferriz
Reported Date 1/5/2009
Location/Project CSUS-FPB
Copy To
Fax (209) 667-3099
e-mail spasakdee@csufresno.edu

		TDS	IDS
		mg/L	mg/L
MCL—>		500	
MDL—>		10	10
RL—>		10	10
SM—>		2540 C	2540 E
EPA—>			
Analysis Date:		12/17/2008	12/17/2008
001 Tomato 1A		19000	5080
002 Tomato 1B	0.5 g NaCl	18000	4020
003 Tomato 1C	1.0 g NaCl	21300	5460
004 Tomato 1D	1.5 g NaCl	21600	6480
005 Tomato 1E	2.0 g NaCl	19600	6580
006 Tomato 2	Natural	34900	11900
007 Tomato 2	0.5 g sugar	33400	11800
008 Tomato 2	1.0 g sugar	35800	11900
009 Tomato 2	1.5 g sugar	37500	12500
010 Tomato 2	2.0 g sugar	40700	12500
011 Fruit cocktail	Natural	71300	1700
012 Fruit cocktail	0.5 g sugar	58000	1060
013 Fruit cocktail	1.0 g sugar	77800	1560
014 Fruit cocktail	1.5 g sugar	50200	900
015 Fruit cocktail	2.0 g sugar	58800	1040
016 Fruit cocktail	0.5 g NaCl	48400	6280
017 Fruit cocktail	1.0 g NaCl	55400	5920
018 Fruit cocktail	1.5 g NaCl	57100	10700
019 Fruit cocktail	2.0 g NaCl	76000	12500

*See external laboratory documentation
MCL = Maximum Contaminant Level according to the California Domestic Water Quality and Monitoring Regulations (Title 22)
MDL = Method Detection Limit; **RL** = Reporting Limit
SM = Standard Methods for the Examination of Water and Wastewater, 19th ed., 1995
EPA = Environmental Protection Agency methods used unless otherwise indicated.
Dissolved metals (**bolded**) were filtered.
MBAS molecular weight = 340 grams.
QA/QC available upon request.

Approved By: ____________________

ELAP Certification #1595

APPENDIX 2

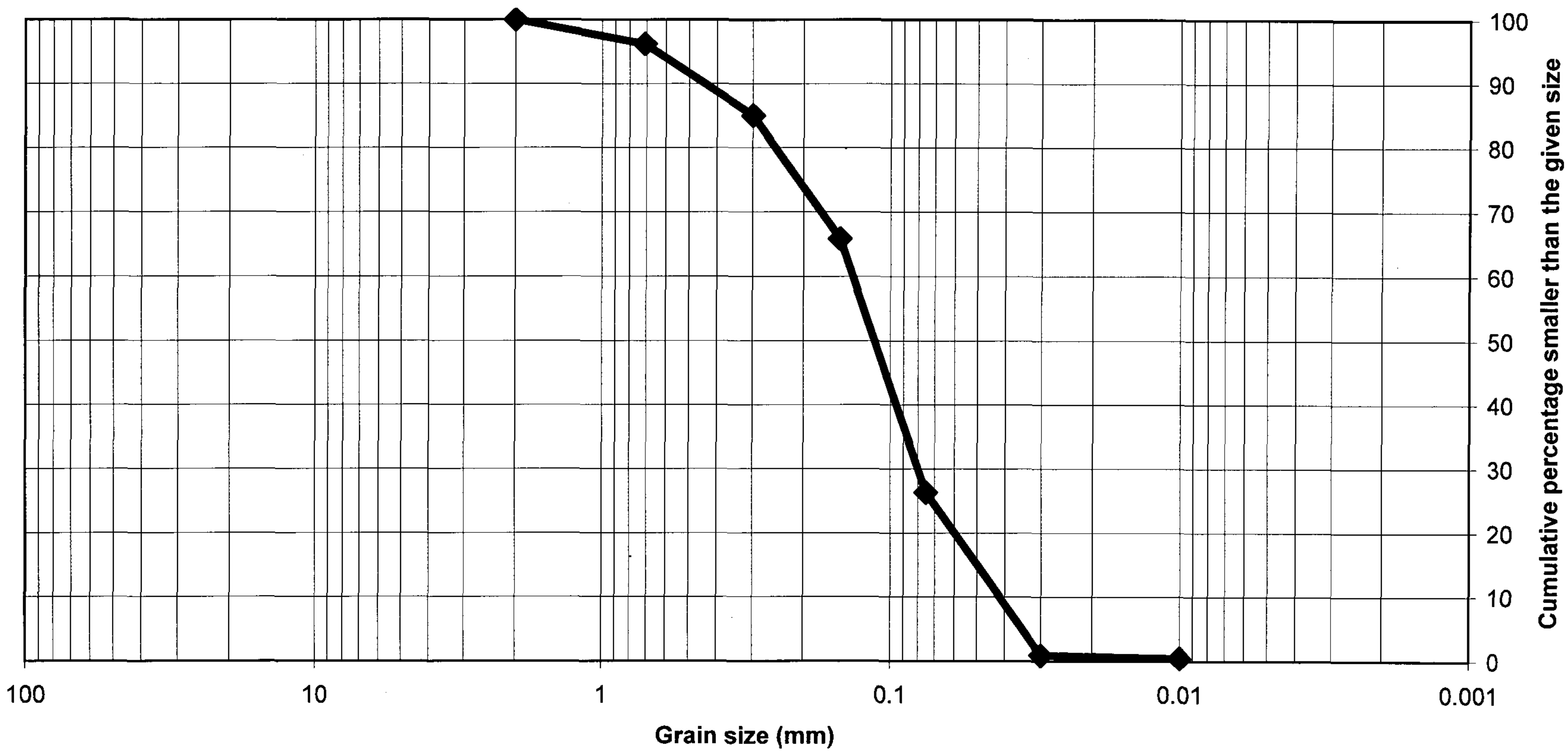
GRAIN-SIZE ANALYSES

AND

PHYSICAL AND CHEMICAL PROPERTIES OF SOILS

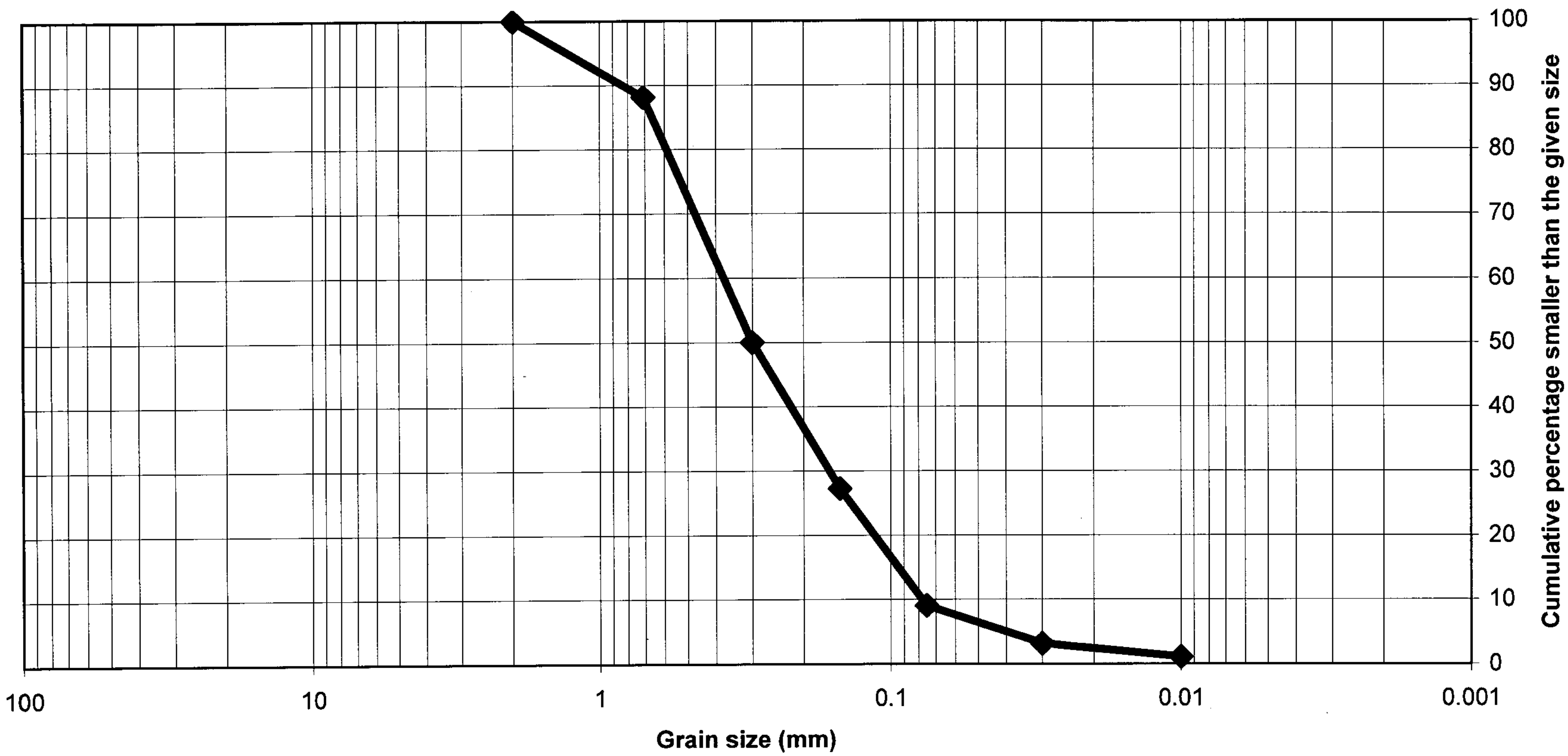
AS REPORTED IN THE NRCS WEB SOIL SURVEY

Soil 1. Ballico sand



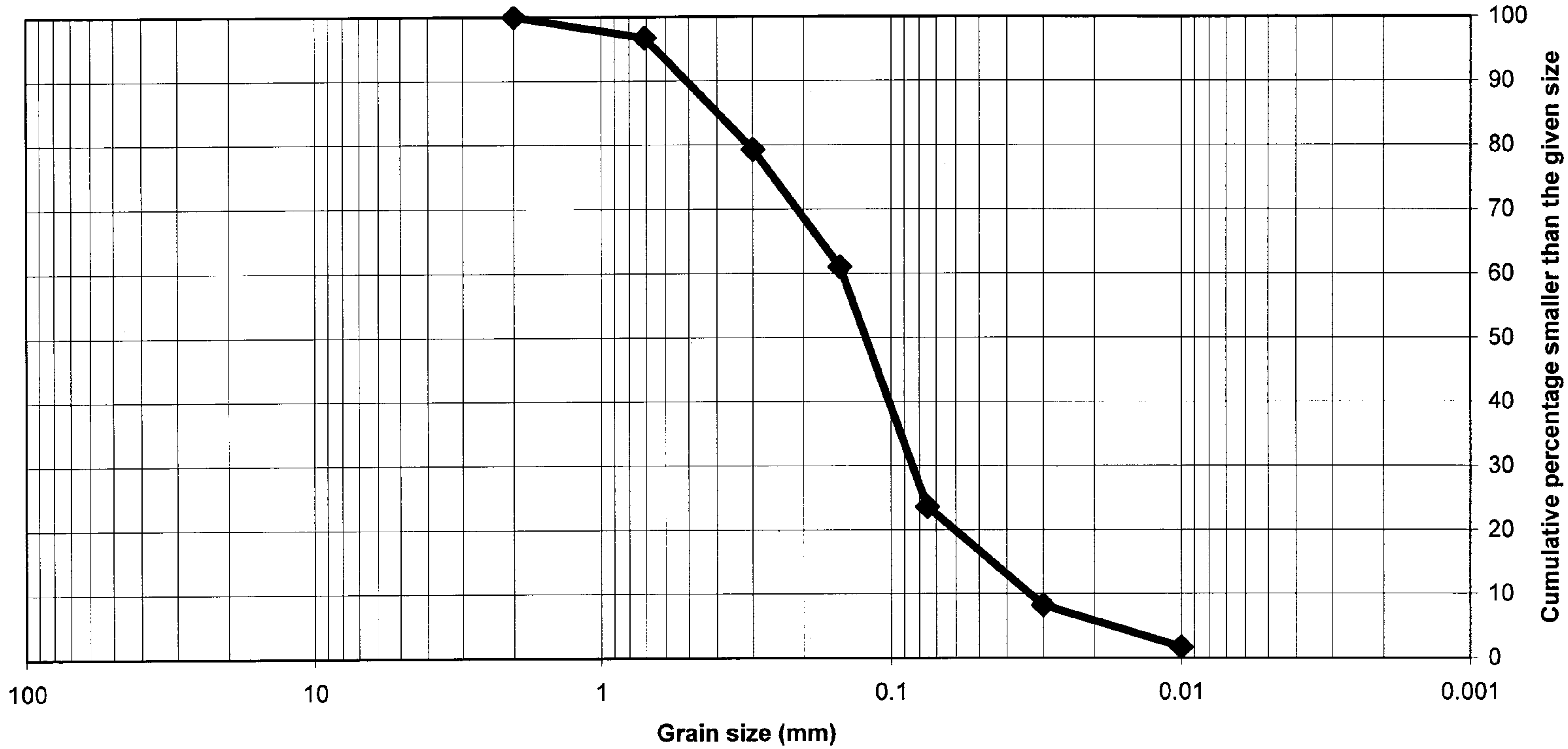
GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY

Soil 2. Turlock sand



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY

Soil 5. Mapes silty sand



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY

Physical properties of soils, as reported in the NRCS Web Soil Survey, 2009
http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*
Soil 1. DgA—Delhi sand, silty substratum, 0 to 3 percent slopes	0-12	-96-	- 2-	0- 3- 5	1.60-1.70	42.00-141.00	0.05-0.08	0.0-2.9	0.5-1.0
	12-30	-96-	- 2-	0- 3- 5	1.60-1.70	42.00-141.00	0.05-0.08	0.0-2.9	0.0-0.5
	30-60	-69-	-22-	5-10-15	1.50-1.60	14.00-42.00	0.13-0.15	0.0-2.9	0.0-0.5
Soil 2. HdpA—Hanford sandy loam, moderately deep over silt, 0 to 1 percent slopes	0-12	-68-	-20-	7-13-18	1.50-1.60	14.00-42.00	0.11-0.13	0.0-2.9	0.5-1.0
	12-36	-68-	-20-	7-13-18	1.50-1.60	14.00-42.00	0.12-0.15	0.0-2.9	0.0-0.5
	36-60	-21-	-55-	20-25- 30	1.45-1.55	1.40-4.00	0.15-0.18	0.0-2.9	0.0-0.5
Soil 3. WoA—Wyman clay loam, 0 to 3 percent slopes	0-14	-34-	-37-	27-29- 30	1.40-1.50	1.40-4.00	0.15-0.19	3.0-5.9	1.0-2.0
	14-41	-35-	-34-	27-31- 35	1.40-1.50	1.40-4.00	0.15-0.18	3.0-5.9	0.0-0.5
	41-60	—	—	15-23- 30	1.40-1.55	1.40-4.00	0.14-0.18	3.0-5.9	0.0-0.5
Soil 4. PaA—Paulsell clay, 0 to 1 percent slopes	0-24	-22-	-28-	40-50- 60	1.30-1.45	0.42-1.40	0.14-0.16	6.0-8.9	1.0-4.0
	24-36	-22-	-28-	40-50- 60	1.30-1.45	0.42-1.40	0.15-0.16	6.0-8.9	0.5-1.0
	36-60	—	—	20-28- 35	1.40-1.55	1.40-4.00	0.14-0.18	3.0-5.9	0.0-0.5
Soil 5. FsA—Fresno fine sandy loam, strongly saline-alkali, 0 to 1 percent slopes	0-5	-69-	-16-	10-15-20	1.45-1.55	4.00-14.00	0.08-0.10	0.0-2.9	0.5-1.0
	5-18	-55-	-17-	20-28- 35	1.35-1.50	0.01-0.42	0.09-0.12	3.0-5.9	0.0-0.5
	18-38	-22-	-55-	20-23- 25	1.45-1.55	0.42-1.40	0.08-0.10	0.0-2.9	0.0-0.5
	38-40	—	—	—	—	0.00-0.01	0	—	—
	40-60	—	—	10-18-25	1.45-1.65	1.40-4.00	0.08-0.12	0.0-2.9	0
Soil 6. TkA—Temple silty clay loam, moderately saline, 0 to 1 percent slopes	0-15	-17-	-48-	30-35- 40	1.35-1.45	0.42-1.40	0.12-0.17	6.0-8.9	1.0-2.0
	15-26	-22-	-28-	40-50- 60	1.30-1.50	0.42-1.40	0.09-0.14	6.0-8.9	0.0-0.5
	26-60	-36-	-34-	25-30- 35	1.40-1.50	1.40-4.00	0.10-0.16	3.0-5.9	0.0-0.5

Chemical properties of soils, as reported in the NRCS Web Soil Survey, 2009
http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

Map symbol and soil name	Depth	Cation-exchange capacity	Effective cation-exchange capacity	Soil reaction	Calcium carbonate	Gypsum	Salinity	Sodium adsorption ratio
	In	*meq/100g*	*meq/100g*	*pH*	*Pct*	*Pct*	*mmhos/cm*	
Soil 1. DgA—Delhi sand, silty substratum, 0 to 3 percent slopes	0-12	1.0-5.0	—	6.1-7.8	0	0	0	0
	12-30	1.0-5.0	—	6.1-7.8	0	0	0	0
	30-60	1.0-5.0	—	6.1-7.8	0	0	0	0
Soil 2. HdpA—Hanford sandy loam, moderately deep over silt, 0 to 1 percent slopes	0-12	5.0-10	—	6.1-7.8	0	0	0	0
	12-36	5.0-10	—	6.1-7.8	0	0	0	0
	36-60	10-15	—	6.1-7.8	0	0	0	0
Soil 3. WoA—Wyman clay loam, 0 to 3 percent slopes	0-14	15-20	—	6.1-7.3	0	0	0	0
	14-41	10-20	—	6.6-7.8	0	0	0	0
	41-60	10-15	—	6.6-8.4	0	0	0.0-2.0	0
Soil 4. PaA—Paulsell clay, 0 to 1 percent slopes	0-24	35-50	—	5.6-7.3	0	0	0	0
	24-36	35-50	—	7.4-8.4	0	0	0.0-2.0	0
	36-60	10-20	—	7.4-8.4	0	0	0.0-4.0	0
Soil 5. FsA—Fresno fine sandy loam, strongly saline-alkali, 0 to 1 percent slopes	0-5	5.0-10	—	7.8-9.6	0-5	0	16.0-30.0	0-5
	5-18	10-20	—	7.8-9.6	0-5	0	16.0-30.0	10-20
	18-38	10-15	—	7.8-9.9	0-5	0	16.0-30.0	10-20
	38-40	—	—	—	—	—	—	—
	40-60	5.0-10	—	7.8-9.6	0-5	0	4.0-16.0	0-5
Soil 6. TkA—Temple silty clay loam, moderately saline, 0 to 1 percent slopes	0-15	15-25	—	7.9-8.4	0	0	8.0-16.0	0
	15-26	25-40	—	7.9-9.0	0	0	8.0-16.0	0
	26-60	10-20	—	7.9-9.0	1-5	0	8.0-16.0	0

APPENDIX 3

INFILTRATION DATA IN SOILS

9/20/08 CSUS Sandy soil. Topmost 3" dry, loose, and with some silt. 6 to 18" sandy, damp, and compact.
Inner ring 16.75 in in diameter
Area 1421.631 cm2

Phase 1 - Constant head experiment

Infiltrometer 1
Water

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	0
500	0.351709	4	0.351709
500	0.351709	10	0.703417
500	0.351709	14	1.055126
500	0.351709	17	1.406835
500	0.351709	19	1.758543
500	0.351709	22	2.110252
500	0.351709	27	2.461961
500	0.351709	33	2.813669
500	0.351709	41	3.165378
500	0.351709	54	3.517087
500	0.351709	61	3.868795
500	0.351709	72	4.220504
500	0.351709	82	4.572213
500	0.351709	95	4.923921
500	0.351709	106	5.27563
500	0.351709	114	5.627339
500	0.351709	121	5.979047
500	0.351709	129	6.330756
500	0.351709	142	6.682465
500	0.351709	151	7.034173
500	0.351709	161	7.385882
500	0.351709	172	7.737591
500	0.351709	180	8.089299
500	0.351709	190	8.441008
500	0.351709	200	8.792717

Infiltrometer 2
Water

Volume (cn	Depth (cm)	Time (min)	Cumulative depth
		0	0
500	0.351709	2	0.351709
500	0.351709	4	0.703417
500	0.351709	6	1.055126
500	0.351709	16	1.406835
500	0.351709	19	1.758543
500	0.351709	24	2.110252
500	0.351709	31	2.461961
500	0.351709	41	2.813669
500	0.351709	48	3.165378
500	0.351709	57	3.517087
500	0.351709	68	3.868795
500	0.351709	77	4.220504
500	0.351709	82	4.572213
500	0.351709	90	4.923921
500	0.351709	98	5.27563
500	0.351709	111	5.627339
500	0.351709	120	5.979047
500	0.351709	131	6.330756
500	0.351709	140	6.682465
500	0.351709	149	7.034173
500	0.351709	157	7.385882
500	0.351709	164	7.737591
500	0.351709	172	8.089299
500	0.351709	187	8.441008
500	0.351709	194	8.792717
500	0.351709	201	9.144425

Infiltrometer 3
Tomato juice

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	0
500	0.351709	3	0.351709
500	0.351709	5	0.703417
500	0.351709	8	1.055126
500	0.351709	15	1.406835
500	0.351709	26	1.758543
500	0.351709	47	2.110252
500	0.351709	58	2.461961
500	0.351709	154	2.813669
500	0.351709	400	3.165378

9/20/08 CSUS Sandy soil. Topmost 3" dry, loose, and with some silt. 6 to 18" sandy, damp, and compact.
Inner ring 16.75 in in diameter
Area 1421.631 cm2

Phase 2 - Falling head experiment

Infiltrometer 1
Water

Time (min)	Head
0	30
12	29.9
238	23
513	16.7
1110	7.3
1260	6

Infiltrometer 2
Water

Time (min)	Head
0	30
12	29.8
238	23.4
513	17.5
1110	7

Infiltrometer 3
Tomato juice

Time (min)	Head
0	30
12	30
238	29
513	28.5
1110	26.4
1260	26
1320	25.8
1490	25.6
1765	24.7
1957	24.6
2658	23.6
2820	23.4
2960	23
3195	22.9

9/20/08 CSUS Sandy soil. Topmost 3" dry, loose, and with some silt. 6 to 18" sandy, damp, and compact.
Inner ring 16.75 in in diameter
Area 1421.631 cm2

Phase 3 - Constant head experiment

Infiltrometer 1
Water

Volume (cr	Depth (cm)	Time (min)	Cumulative depth

Infiltrometer 2
Tomato juice

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	0
500	0.351709	15	0.351709
500	0.351709	45	0.703417
500	0.351709	73	1.055126
500	0.351709	100	1.406835
500	0.351709	125	1.758543
500	0.351709	150	2.110252
500	0.351709	190	2.461961

9/20/08 CSUS Sandy soil. Topmost 3" dry, loose, and with some silt. 6 to 18" sandy, damp, and compact.
Inner ring 16.75 in in diameter
Area 1421.631 cm2

Phase 2 - Falling head experiment

Infiltrometer 1
Water

Time (min)	Head
0	30
170	26.5
445	21.4
637	19.5
1338	9.6
1500	7.9
1640	6.9
1875	3.5

Infiltrometer 2
Tomato juice

Time (min)	Head
0	30
170	28.3
445	26.2
637	25.3
1338	23.2
1500	23
1640	22.9
1875	22.2

Infiltrometer 3
Tomato juice

Time (min)	Head
0	30
12	30
238	29
513	28.5
1110	26.4
1260	26
1320	25.8
1490	25.6
1765	24.7
1957	24.6
2658	23.6
2820	23.4
2960	23
3195	22.9

10/11/08 Merced SC soil
Inner ring 16.75 in in diameter
Area 1421.631 cm2
Phase 1 - Constant head experiment

Infiltrometer 4
Water

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	0
500	0.351709	0.50032	0.351709
500	0.351709	0.883899	0.703417
500	0.351709	1.417574	1.055126
500	0.351709	1.917894	1.406835
500	0.351709	2.56831	1.758543
500	0.351709	3.3855	2.110252
500	0.351709	4.319431	2.461961
500	0.351709	5.236685	2.813669
500	0.351709	6.537517	3.165378
500	0.351709	7.688254	3.517087
500	0.351709	8.989086	3.868795
500	0.351709	10.50672	4.220504
500	0.351709	12.05772	4.572213
500	0.351709	13.67542	4.923921
500	0.351709	14.75945	5.27563
500	0.351709	16.82744	5.627339
500	0.351709	18.47849	5.979047
500	0.351709	21.24693	6.330756
500	0.351709	22.19754	6.682465
500	0.351709	24.13211	7.034173
500	0.351709	25.79985	7.385882
500	0.351709	28.28477	7.737591
500	0.351709	30.2527	8.089299
500	0.351709	32.28733	8.441008
500	0.351709	35.48938	8.792717
500	0.351709	36.90695	9.144425
500	0.351709	39.0083	9.496134
500	0.351709	41.76006	9.847843
500	0.351709	43.74466	10.19955
500	0.351709	46.02946	10.55126
500	0.351709	48.34761	10.90297
500	0.351709	50.84921	11.25468
500	0.351709	53.88449	11.60639
500	0.351709	55.96915	11.95809

Infiltrometer 5
Water

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	0
500	0.351709	0.400256164	0.351709
500	0.351709	0.483642865	0.703417
500	0.351709	0.733802967	1.055126
500	0.351709	0.98396307	1.406835
500	0.351709	1.450928594	1.758543
500	0.351709	1.684411357	2.110252
500	0.351709	2.318150283	2.461961
500	0.351709	2.935211869	2.813669
500	0.351709	3.502241435	3.165378
500	0.351709	4.152657701	3.517087
500	0.351709	5.05323407	3.868795
500	0.351709	5.787037037	4.220504
500	0.351709	6.687613406	4.572213
500	0.351709	7.271320312	4.923921
500	0.351709	8.15521934	5.27563
500	0.351709	9.039118369	5.627339
500	0.351709	10.20653218	5.979047
500	0.351709	10.97368983	6.330756
500	0.351709	12.02436226	6.682465
500	0.351709	14.3258352	7.034173
500	0.351709	15.20973423	7.385882
500	0.351709	16.17701996	7.737591
500	0.351709	17.86143132	8.089299
500	0.351709	18.16162344	8.441008
500	0.351709	19.56252001	8.792717
500	0.351709	20.36303234	9.144425
500	0.351709	22.26424912	9.496134
500	0.351709	23.11479347	9.847843
500	0.351709	23.69850037	10.19955
500	0.351709	25.51633045	10.55126
500	0.351709	27.78444871	10.90297
500	0.351709	29.15199061	11.25468
500	0.351709	30.31940442	11.60639
500	0.351709	31.63691429	11.95809

Infiltrometer 6
Tomato juice

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	0
500	0.351709	0.833867	0.351709
500	0.351709	1.050672	0.703417
500	0.351709	1.267478	1.055126
500	0.351709	1.701089	1.406835
500	0.351709	3.302113	1.758543
500	0.351709	7.855027	2.110252
500	0.351709	12.22449	2.461961
500	0.351709	17.09427	2.813669
500	0.351709	35.93967	3.165378
500	0.351709	50.83253	3.517087
500	0.351709	80.96849	3.868795
500	0.351709	103.0159	4.220504
500	0.351709	130.2333	4.572213
1500	1.055126	254.9799	5.627339
500	0.351709	306.8464	5.979047

500	0.351709	59.48807	12.3098
500	0.351709	61.47268	12.66151
500	0.351709	63.8075	13.01322
500	0.351709	66.2424	13.36493
500	0.351709	69.67793	13.71664
500	0.351709	72.14617	14.06835
500	0.351709	75.53167	14.42006
500	0.351709	77.69973	14.77176
500	0.351709	81.70229	15.12347
500	0.351709	85.28792	15.47518
500	0.351709	87.17246	15.82689
500	0.351709	90.17438	16.1786
500	0.351709	92.95949	16.53031
500	0.351709	96.7786	16.88202
500	0.351709	99.69714	17.23372
500	0.351709	101.9653	17.58543
500	0.351709	104.9672	17.93714
500	0.351709	107.9357	18.28885
500	0.351709	111.4213	18.64056
500	0.351709	115.3738	18.99227
500	0.351709	117.4752	19.34398
500	0.351709	119.7099	19.69569
500	0.351709	123.1955	20.04739
500	0.351709	127.2648	20.3991
500	0.351709	131.2507	20.75081
500	0.351709	133.302	21.10252
500	0.351709	137.6714	21.45423
500	0.351709	142.4745	21.80594
500	0.351709	144.7426	22.15765
500	0.351709	146.8273	22.50935
500	0.351709	151.597	22.86106
500	0.351709	154.1153	23.21277
500	0.351709	156.8837	23.56448
500	0.351709	160.8696	23.91619
500	0.351709	165.1891	24.2679
500	0.351709	168.241	24.61961
500	0.351709	171.7933	24.97132
500	0.351709	173.8946	25.32302
500	0.351709	180.232	25.67473
500	0.351709	183.4174	26.02644
500	0.351709	186.5694	26.37815
9500	6.682465	262.1178	33.06061
8625	6.066974	347.3223	39.12759

500	0.351709	33.23793895	12.3098
500	0.351709	34.4220301	12.66151
500	0.351709	35.85628135	13.01322
500	0.351709	37.99098089	13.36493
500	0.351709	39.72542427	13.71664
500	0.351709	42.54389476	14.06835
500	0.351709	43.84472729	14.42006
500	0.351709	45.57917067	14.77176
500	0.351709	46.59648842	15.12347
500	0.351709	47.68051553	15.47518
500	0.351709	49.18147614	15.82689
500	0.351709	50.83253282	16.1786
500	0.351709	51.86652791	16.53031
500	0.351709	53.0672964	16.88202
500	0.351709	54.90180382	17.23372
500	0.351709	56.91976198	17.58543
500	0.351709	59.52142705	17.93714
500	0.351709	61.30590244	18.28885
500	0.351709	61.98967339	18.64056
500	0.351709	65.67536557	18.99227
500	0.351709	66.69268332	19.34398
500	0.351709	69.06086562	19.69569
500	0.351709	70.44508485	20.04739
500	0.351709	72.59646174	20.3991
500	0.351709	74.38093713	20.75081
500	0.351709	76.58234603	21.10252
500	0.351709	77.33282634	21.45423
500	0.351709	80.36810225	21.80594
500	0.351709	80.91845448	22.15765
500	0.351709	83.52011954	22.50935
500	0.351709	84.92101612	22.86106
500	0.351709	87.25584374	23.21277
500	0.351709	89.55731668	23.56448
500	0.351709	91.87546697	23.91619
500	0.351709	94.49380937	24.2679
500	0.351709	95.94473797	24.61961
500	0.351709	97.92934145	24.97132

10/11/08 Merced SC soil
Inner ring 16.75 in in diameter
Area

Phase 2 - Falling head experiment

Infiltrometer 3			Infiltrometer 4		Infiltrometer 5	
Water			Water		Tomato juice	
Time (min)	Head		Time (min)	Head	Time (min)	Head
0	30	11:30:13	0	30	0	30
77.63302	25	11:40:00	9.789599	28.5	82.90306	29.5
190.7888	19.1	11:50:00	19.796	27	188.8042	29
767.3578	3.4	13:23:00	112.8556	15	275.443	28.6
803.8144	2.9	13:43:00	132.8684	12	347.9894	28.4
882.6816	1	14:21:20	171.2263	9.8	461.3286	28
		14:43:54	193.8074	7.2		
		15:32:04	242.0049	3.7		
		15:44:20	254.2794	2.9	1236.81	26.3
					3240.941	23.8
					3939.138	23.2
					4675.509	22.6

10/11/08 Merced SC soil
Inner ring 16.75 in in diameter
Area 1421.631 cm2

Phase 3 - Constant head experiment

Infiltrometer 4
Water

Volume (cr	Depth (cm)	Time (min)	Cumulative depth

Infiltrometer 5
Tomato juice

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	0
500	0.351709	4.869783	0.351709
500	0.351709	7.971769	0.703417
500	0.351709	18.5452	1.055126
500	0.351709	32.17059	1.406835
500	0.351709	45.84601	1.758543
2500	1.758543	117.9421	3.517087
2000	1.406835	204.5809	4.923921

10/11/08 Merced SC soil

Inner ring 16.75 in in diameter

Area 1421.631 cm2

Phase 2 - Falling head experiment

Infiltrometer 4

Water

Time (min)	Head

Infiltrometer 5

Tomato juice

Time (min)	Head
0	30
73.84726	29.4
186.8863	29.3
763.4219	25.8
878.8958	25.3
2886.531	22.6
3584.177	22.1
4200.438	21.3

10/26/08 Ballico bio farm. SP wind-blown sand.
Inner ring 16.75 in in diameter
Area 1421.631 cm2
Phase 1 - Constant head experiment

Infiltrometer 10
Water

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	0
500	0.351709	0.333547	0.351709
500	0.351709	0.583707	0.703417
500	0.351709	0.833867	1.055126
500	0.351709	1.250801	1.406835
500	0.351709	1.584347	1.758543
500	0.351709	1.917894	2.110252
500	0.351709	2.418214	2.461961
500	0.351709	2.918535	2.813669
500	0.351709	3.502241	3.165378
500	0.351709	4.169335	3.517087
500	0.351709	4.586269	3.868795
500	0.351709	5.253362	4.220504
500	0.351709	5.920456	4.572213
500	0.351709	6.620904	4.923921
500	0.351709	7.454771	5.27563
500	0.351709	8.472089	5.627339
500	0.351709	9.856308	5.979047
500	0.351709	10.92366	6.330756
500	0.351709	12.00768	6.682465
500	0.351709	13.1751	7.034173
500	0.351709	14.50929	7.385882
500	0.351709	15.84347	7.737591
500	0.351709	17.34443	8.089299
500	0.351709	18.59523	8.441008
500	0.351709	20.09619	8.792717
500	0.351709	21.44706	9.144425
500	0.351709	22.51441	9.496134
500	0.351709	24.01537	9.847843
500	0.351709	25.44962	10.19955
500	0.351709	26.85052	10.55126
500	0.351709	28.35148	10.90297
500	0.351709	29.26873	11.25468
500	0.351709	30.81972	11.60639
500	0.351709	32.35404	11.95809

Infiltrometer 11
Water

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	0
500	0.351709	0.917253709	0.351709
500	0.351709	1.584347316	0.703417
500	0.351709	2.418214324	1.055126
500	0.351709	3.585628135	1.406835
500	0.351709	4.669655246	1.758543
500	0.351709	5.837069058	2.110252
500	0.351709	7.421416373	2.461961
500	0.351709	8.588830185	2.813669
500	0.351709	9.923017398	3.165378
500	0.351709	11.25720461	3.517087
500	0.351709	13.10838937	3.868795
500	0.351709	14.92621945	4.220504
500	0.351709	16.84411357	4.572213
500	0.351709	18.42846088	4.923921
500	0.351709	19.76264809	5.27563
500	0.351709	21.59715551	5.627339
500	0.351709	23.34827623	5.979047
500	0.351709	25.59971715	6.330756
500	0.351709	27.51761127	6.682465
500	0.351709	29.18534529	7.034173
500	0.351709	30.936466	7.385882
500	0.351709	32.60420002	7.737591
500	0.351709	34.77225424	8.089299
500	0.351709	37.10708187	8.441008
500	0.351709	38.60804248	8.792717
500	0.351709	40.69271	9.144425
500	0.351709	42.69399082	9.496134
500	0.351709	44.52849824	9.847843
500	0.351709	46.44639236	10.19955
500	0.351709	48.86460668	10.55126
500	0.351709	50.3655673	10.90297
500	0.351709	52.95055502	11.25468
500	0.351709	54.78506244	11.60639
500	0.351709	56.45279646	11.95809

Infiltrometer 12
Tomato juice

Volume (cr	Depth (cm)	Time (min)	Cumulative depth	
		0	0	
500	0.351709	0.50032	0.351709	0:00:30
500	0.351709	1.167414	0.703417	0:00:40
500	0.351709	2.084668	1.055126	0:00:55
500	0.351709	3.502241	1.406835	0:01:25
500	0.351709	4.669655	1.758543	0:01:10
500	0.351709	6.754323	2.110252	0:02:05
500	0.351709	11.02372	2.461961	0:04:16
500	0.351709	14.25913	2.813669	0:03:14
500	0.351709	17.76137	3.165378	0:03:30
500	0.351709	20.6799	3.517087	0:02:55
500	0.351709	25.84988	3.868795	0:05:10
500	0.351709	30.93647	4.220504	0:05:05
500	0.351709	35.35596	4.572213	0:04:25
500	0.351709	39.94223	4.923921	0:04:35
500	0.351709	46.44639	5.27563	0:06:30
1000	0.703417	59.45472	5.979047	0:13:00
500	0.351709	66.29243	6.330756	0:06:50
500	0.351709	74.46432	6.682465	0:08:10
500	0.351709	81.80235	7.034173	0:07:20
500	0.351709	89.47393	7.385882	0:07:40
500	0.351709	97.8126	7.737591	0:08:20

500	0.351709	33.82165	12.3098
500	0.351709	34.52209	12.66151
500	0.351709	35.85628	13.01322
500	0.351709	37.35724	13.36493
500	0.351709	38.92491	13.71664
500	0.351709	39.94223	14.06835
500	0.351709	41.52658	14.42006
500	0.351709	42.86076	14.77176
500	0.351709	44.27834	15.12347
500	0.351709	45.44575	15.47518
500	0.351709	46.44639	15.82689
500	0.351709	48.36429	16.1786
500	0.351709	49.69847	16.53031
500	0.351709	51.44959	16.88202
500	0.351709	52.86717	17.23372
500	0.351709	54.28474	17.58543
500	0.351709	55.7857	17.93714
500	0.351709	57.0365	18.28885
500	0.351709	58.2873	18.64056
500	0.351709	59.5381	18.99227
500	0.351709	60.53874	19.34398
500	0.351709	62.37325	19.69569
500	0.351709	63.70744	20.04739
500	0.351709	64.87485	20.3991
500	0.351709	66.37581	20.75081
500	0.351709	67.71	21.10252
500	0.351709	69.29435	21.45423

500	0.351709	59.12117088	12.3098
500	0.351709	61.2058384	12.66151
500	0.351709	62.62341232	13.01322
500	0.351709	65.12501334	13.36493
500	0.351709	66.62597396	13.71664
500	0.351709	68.87741488	14.06835

10/26/08 Ballico bio farm. SP wind-blown sand.
Inner ring 16.75 in in diameter
Area cm2

Phase 2 - Falling head experiment

Infiltrometer 10		Infiltrometer 11		Infiltrometer 12	
Water		Water		Tomato juice	
Time (min)	Head	Time (min)	Head	Time (min)	Head
0	30	0	30	0	30
6.003842	28.3	4.25	29.5	6.67	29.5
17.67798	25.5	5.00	28.4	10.01	29.2
36.02305	21.4	10.0064	27.5	45.02882	28.2
51.03266	18.4	16.01025	26.6	75.04803	27.1
64.04099	15.6	20.01281	25.9	90.05764	26.5
80.05123	12.8	25.01601	25.1	120.0768	25.9
92.05892	11	55.03522	21.2	134.0858	25.5
		85.05443	17	155.0993	25
		100.064	15.2	180.1153	24.1
		110.0704	13.9	194.1242	24
		129.3328	11.7	210.1345	23.7
		143.0916	10.4	228.146	23.5
		150.5964	9.7	256.1639	23
				285.1825	22.6

10/26/08 Ballico bio farm. SP wind-blown sand.
Inner ring 16.75 in in diameter
Area 1421.631 cm2
Phase 3 - Constant head experiment

Infiltrometer 10
Clear water

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	0
500	0.351709	1.00064	0.351709
500	0.351709	2.334828	0.703417
500	0.351709	3.669015	1.055126
500	0.351709	5.503522	1.406835
500	0.351709	6.837709	1.758543
500	0.351709	7.704931	2.110252
500	0.351709	10.08979	2.461961
500	0.351709	11.2572	2.813669
500	0.351709	12.84155	3.165378
500	0.351709	13.95893	3.517087
500	0.351709	15.42654	3.868795
500	0.351709	17.09427	4.220504
500	0.351709	18.34507	4.572213
500	0.351709	20.26297	4.923921
500	0.351709	21.54712	5.27563
500	0.351709	22.84796	5.627339
500	0.351709	24.18214	5.979047
500	0.351709	25.71646	6.330756
500	0.351709	27.01729	6.682465
500	0.351709	28.26809	7.034173
500	0.351709	29.80241	7.385882
500	0.351709	31.27001	7.737591
500	0.351709	32.6042	8.089299
500	0.351709	34.10516	8.441008
500	0.351709	35.52273	8.792717
500	0.351709	36.77354	9.144425
500	0.351709	38.19111	9.496134
500	0.351709	39.60868	9.847843

Infiltrometer 11
Tomato juice

Volume (cr	Depth (cm)	Time (min)	Cumulative
		0	0
500	0.351709	4.703009926	0.351709
500	0.351709	7.371384353	0.703417
500	0.351709	10.95701249	1.055126
500	0.351709	13.04168001	1.406835
500	0.351709	16.01024656	1.758543
500	0.351709	19.87938948	2.110252
500	0.351709	22.88131071	2.461961
500	0.351709	26.08336002	2.813669
500	0.351709	29.55224677	3.165378
500	0.351709	32.1372345	3.517087
500	0.351709	36.38995624	3.868795
500	0.351709	39.39187747	4.220504
500	0.351709	42.2270253	4.572213
500	0.351709	45.97942683	4.923921
500	0.351709	50.06537517	5.27563
500	0.351709	53.65100331	5.627339
500	0.351709	56.90308464	5.979047
500	0.351709	62.23983349	6.330756
500	0.351709	66.24239513	6.682465
500	0.351709	70.41173017	7.034173
500	0.351709	74.08074501	7.385882
500	0.351709	77.91653325	7.737591
500	0.351709	83.5034422	8.089299
1100	0.773759	92.67597929	8.863058
1090	0.766725	102.5989967	9.629783
1030	0.72452	112.3552407	10.3543
1295	0.910925	123.0287384	11.26523
995	0.6999	132.2846622	11.96513

500	0.351709	41.22638	10.19955
500	0.351709	42.36044	10.55126
500	0.351709	43.69463	10.90297
500	0.351709	45.02882	11.25468
500	0.351709	46.52978	11.60639
500	0.351709	47.86397	11.95809
500	0.351709	49.33157	12.3098
500	0.351709	50.86589	12.66151
500	0.351709	52.0333	13.01322
500	0.351709	52.86717	13.36493
500	0.351709	54.33477	13.71664
500	0.351709	55.95248	14.06835
500	0.351709	57.20328	14.42006
500	0.351709	58.62085	14.77176
500	0.351709	60.12181	15.12347
500	0.351709	61.73951	15.47518
500	0.351709	63.12373	15.82689
500	0.351709	64.70808	16.1786

1000	0.703417	142.7913865	12.66855

11/16/08 Claribel Ranch SC - Clayey sand Same soil as used in L-6 through L-10
Inner ring 16.75 in in diameter
Area 1421.631 cm2
Phase 1 - Constant head experiment

Infiltrometer 13
Water

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	0
500	0.351709	0.883899	0.351709
500	0.351709	1.851185	0.703417
500	0.351709	4.102626	1.055126
500	0.351709	7.187934	1.406835
500	0.351709	11.44066	1.758543
500	0.351709	17.52788	2.110252
390	0.274333	29.75237	2.384585
400	0.281367	42.41048	2.665952
500	0.351709	55.25203	3.01766
405	0.284884	65.15837	3.302544
200	0.140683	74.71448	3.443228
180	0.126615	85.53808	3.569843
285	0.200474	95.14423	3.770317

Infiltrometer 14
Water

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	0
500	0.351709	5.286716832	0.351709
500	0.351709	7.938413918	0.703417
500	0.351709	11.30723663	1.055126
500	0.351709	14.77612339	1.406835
500	0.351709	17.77804462	1.758543
500	0.351709	21.44705945	2.110252
500	0.351709	24.94930089	2.461961
1440	1.012921	37.57404739	3.474882
1500	1.055126	51.24946633	4.530008
1300	0.914443	61.63944925	5.44445
390	0.274333	66.67600598	5.718783
555	0.390397	73.04674992	6.109179
500	0.351709	78.23340271	6.460888
445	0.313021	82.93641264	6.773909
455	0.320055	87.82287331	7.093964
655	0.460738	94.21029459	7.554702
340	0.239162	99.0300459	7.793864
465	0.327089	103.9665386	8.120953

Infiltrometer 15
Tomato juice

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	0
500	0.351709	10.60679	0.351709
500	0.351709	23.59844	0.703417
1000	0.703417	48.18084	1.406835
370	0.260264	65.40853	1.667099
340	0.239162	83.48676	1.906261
255	0.179371	102.6991	2.085632
290	0.203991	118.159	2.289623

11/16/08 Claribel Ranch SC - Clayey sand Same soil as used in L-6 through L-10
Inner ring 16.75 in in diameter
Area 1421.631
Phase 2 - Falling head experiment

Infiltrometer 13		Infiltrometer 14		Infiltrometer 15	
Water		Water		Tomato juice	
Time (min)	Head	Time (min)	Head	Time (min)	Head
0	30	0	30	0	30
12.94162	29.7	15.38	29	14.39	29.9
18.6953	29.6	6.05	28.9	13.88	29.7
33.68823	29.3	10.62347	28.5	108.5528	28.9
130.9505	28	20.39639	28	140.4566	28.8
160.5361	27.7	116.7247	23.7	182.0832	28.2
		146.9274	22.5	196.9094	28.2
				248.2255	28
				271.5238	28

11/16/08 Claribel Ranch SC - Clayey sand Same soil as used in L-6 through L-10
Inner ring 16.75 in in diameter
Area 1421.631 cm2
Phase 3 - Constant head experiment

Infiltrometer 13
Clear water

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	0
500	0.351709	24.16547	0.351709
475	0.334123	57.75363	0.685832
660	0.464255	93.50985	1.150087
230			

Infiltrometer 14 Partial amount of tomato paste
Tomato juice

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	0
500	0.351709	13.67541893	0.351709
500	0.351709	21.81396093	0.703417
500	0.351709	39.19174939	1.055126
450	0.316538	52.16672003	1.371664
500	0.351709	70.82866368	1.723372
785	0.552183	106.4514623	2.275555
340	0.239162	126.9645907	2.514717

APPENDIX 4

MOISTURE AND ELECTRIC CONDUCTIVITY MEASUREMENTS

Ballico sand

	TDS	Depth	EC	Depth	Depth	pH	MOISTURI	DEPTH
DRY	46	0	94	0	0	6.15	4.00	0
	47	12	93	12	12	6.24	9.36	12
	32	18	66	18	18	6.51	8.63	18
	55	24	100	24	24	6.23	9.99	24
	34	30	69	30	30	6.42	5.43	30
	26	36	53	36	36	6.61	14.84	36
	42	42	75	42	42	5.97	6.41	42
	19	46	38	46	46	6.73	17.60	48
	26	56	52	56	56	6.64	22.02	56
I-10	63	0	122	0	0	6.36	7.87	0
	56	6	118	6	6	6.11	4.95	6
	56	12	117	12	12	6.27	10.51	12
	57	24	120	24	24	5.99	8.60	24
	52	30	105	30	30	6.25	20.45	30
	32	36	61	36	36	6.67	13.84	36
	50	42	100	42	42	6.41	16.94	42
	31	44	63	44	44	6.46	21.78	44
I-11	185	0	378	0	0.00	5.1	14.08	0
	69	6	142	6	6.00	6.23	9.61	6
	66	12	148	12	12.00	6.6	15.17	12
	195	18	194	18	18.00	6.47	17.71	18
	66	24	131	24	24.00	6.95	14.72	24
	116	30	135	30	30.00	5.83	11.06	30
	71	36	142	36	36.00	6	13.68	36
	28	42	56	42	42.00	6.52	11.50	42
	31	48	62	48	48.00	6.27	8.80	48
	20	54	41	54	54.00	6.62	25.18	54
I-12								
	170	0	335	0	0	5.23	15.61	0
	69	6	153	6	6	6.45	11.46	6
	108	12	215	12	12	5.97	12.73	12
	30	18	60	18	18	6.08	8.49	18
	37	24	75	24	24	5.97	4.65	24
	48	30	99	30	30	5.89	5.11	30
	37	36	74	36	36	6.01	11.01	36

CSUS sand

	TDS	Depth	EC	Depth	pH	Depth		MOISTURI	DEPTH
I-1/dry	228	6	612	6	5.69	6	I-1	0.93	6
	75	12	133	12	6.11	12		3.83	12
	60	15	132	15	5.81	15		3.97	15
I-3	153	6	278	6	4.88	6	I-3	13.66	6
	127	9	252	9	5.79	9		8.38	9
	84	12	185	12	6.65	12		7.94	12
	104	15	210	15	5.9	15		8.67	15

Merced clay

	TDS	Depth	EC	Depth	pH	Depth	MOISTURI	DEPTH
DRY	303	0	592	0	5.23	0	3	0
	352	6	705	6	5.32	6	3.78	6
I-4	457	0	935	0	5.45	0	30.25	0
	172	3	379	3	5.86	3	15.65	3
	266	6	572	6	6.16	6	22.52	6
	226	9	500	9	6.19	9	16.59	9
	240	12	468	12	6.66	12	17.76	12
	231	18	466	18	6.54	18	17.53	18
	217	22	430	22	6.59	22	13.18	22
	214	29	412	29	6.4	29	13.25	29
	213	33	359	33	6.55	33	14.34	33
	205	36	492	36	6.29	36	14.42	36
	201	39	384	39	6.37	39	14.48	39
I-5	618	0	1226	0	4.97	0	68.16	0
	256	6	514	6	6.01	6	22.14	6
	189	9	377	9	6.14	9	21.41	9
	186	14	381	14	6.35	14	18.65	14
	190	21	383	21	6.59	21	15.28	21
	212	33	374	33	6.98	33	17.87	33
	214	36	433	36	6.92	36	20.70	36
	210	40	437	40	6.75	40	15.74	40
	276	43	472	43	6.82	43	14.87	43
I-6	172	0	343	0	5.69	0	11.42	0
	184	9	369	9	6.3	9	13.79	9
	188	14	382	14	6.37	14	14.62	14
	161	21	322	21	6.73	21	16.44	21
	181	24	359	24	6.55	24	17.73	24
	196	30	393	30	6.71	30	19.22	30
	190	36	381	36	6.86	36	15.08	36
	199	39	399	39	6.77	39	14.27	40
	229	42	447	42	6.83	42	13.34	42

Oakdale clay

	TDS	Depth	EC	Depth	pH	Depth	MOISTURI	DEPTH
I-13	231	0	466	0	6.79	0	22.43	0
	212	6	426	6	6.83	6	19.94	6
	197	12	392	12	6.88	12	20.15	12
	430	12	866	12	7.17	12	21.26	12
I-14	0	18			0	18	19.27	18
	262	30	527	30	6.76	30	16.54	30
	435	0	872	0	7.21	0	18.39	0
	0	12			0	12	21.68	12
	0	18			0	18	14.80	18
I-15	357	20	717	20	6.15	20	16.29	20

APPENDIX 5

INFILTRATION DATA ON ASPHALT AND CONCRETE

10/25/08 Waterford aged asphalt and concrete
Inner ring 16.75 in in diameter
Area 1421.631 *cm2*
Phase 1 - Constant head experiment

Infiltrometer 7
Water

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	*0*
500	0.351709	0.56703	0.351709
500	0.351709	0.833867	0.703417
500	0.351709	1.250801	1.055126
500	0.351709	1.751121	1.406835
500	0.351709	2.418214	1.758543
500	0.351709	3.202049	2.110252
500	0.351709	3.919175	2.461961
500	0.351709	4.586269	2.813669
500	0.351709	5.253362	3.165378
500	0.351709	5.920456	3.517087
500	0.351709	6.754323	3.868795
500	0.351709	7.671576	4.220504
500	0.351709	8.755604	4.572213
500	0.351709	9.923017	4.923921
500	0.351709	10.75688	5.27563
500	0.351709	11.75752	5.627339
500	0.351709	12.50801	5.979047
500	0.351709	13.59203	6.330756
500	0.351709	14.75945	6.682465
500	0.351709	15.92686	7.034173
500	0.351709	17.21102	7.385882
500	0.351709	18.51185	7.737591
500	0.351709	19.92942	8.089299
500	0.351709	20.93006	8.441008
500	0.351709	22.68118	8.792717
500	0.351709	23.8486	9.144425
500	0.351709	25.59972	9.496134
500	0.351709	27.35084	9.847843
500	0.351709	29.26873	10.19955
500	0.351709	30.9865	10.55126
500	0.351709	32.6042	10.90297
500	0.351709	34.60548	11.25468
500	0.351709	36.77354	11.60639
500	0.351709	38.60804	11.95809
500	0.351709	40.14236	12.3098
500	0.351709	42.27706	12.66151
500	0.351709	43.8614	13.01322
500	0.351709	46.19623	13.36493

Infiltrometer 8
Water Cracks kept opening throughout the experiment, :

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	*0*
20000	14.06835	0.583706906	14.06835
20000	14.06835	1.250800512	28.13669
20000	14.06835	1.917894119	42.20504
20000	14.06835	2.668374426	56.27339
20000	14.06835	3.252081332	70.34173
20000	14.06835	3.919174939	84.41008
20000	14.06835	4.669655246	98.47843
20000	14.06835	5.253362152	112.5468
20000	14.06835	5.920455758	126.6151
20000	14.06835	6.587549365	140.6835
20000	14.06835	7.171256271	154.7518
20000	14.06835	7.921736578	168.8202
20000	14.06835	8.505443484	182.8885
20000	14.06835	9.17253709	196.9569
20000	14.06835	9.839630697	211.0252
20000	14.06835	10.5067243	225.0935
20000	14.06835	11.00704451	239.1619
20000	14.06835	11.75752482	253.2302
20000	14.06835	12.42461842	267.2986
20000	14.06835	13.09171203	281.3669
20000	14.06835	13.67541893	295.4353
20000	14.06835	14.34251254	309.5036
20000	14.06835	15.00960615	323.572
20000	14.06835	16.31043868	337.6403
20000	14.06835	16.92750027	351.7087
20000	14.06835	17.59459387	365.777
20000	14.06835	18.26168748	379.8454
20000	14.06835	18.84539439	393.9137
20000	14.06835	19.42910129	407.9821
20000	14.06835	20.0961949	422.0504
20000	14.06835	20.7632885	436.1187
20000	14.06835	21.34699541	450.1871
20000	14.06835	22.09747572	464.2554
20000	14.06835	22.68118262	478.3238
20000	14.06835	23.34827623	492.3921
20000	14.06835	24.01536984	506.4605
20000	14.06835	24.51569004	520.5288
20000	14.06835	25.26617035	534.5972

Infiltrometer 9
Tomato juice

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	*0*
500	0.351709	0.75048	0.351709
500	0.351709	0.900576	0.703417
500	0.351709	1.300833	1.055126
500	0.351709	1.467606	1.406835
500	0.351709	1.734443	1.758543
500	0.351709	2.234764	2.110252
500	0.351709	2.551633	2.461961
500	0.351709	2.81847	2.813669
500	0.351709	3.318791	3.165378
500	0.351709	3.552273	3.517087
500	0.351709	3.95253	3.868795
500	0.351709	4.252722	4.220504
500	0.351709	4.45285	4.572213
500	0.351709	4.753042	4.923921
500	0.351709	5.236685	5.27563
500	0.351709	5.653618	5.627339
500	0.351709	5.920456	5.979047
500	0.351709	6.387421	6.330756
500	0.351709	6.670936	6.682465
500	0.351709	6.904419	7.034173
500	0.351709	7.27132	7.385882
500	0.351709	7.688254	7.737591
500	0.351709	7.888382	8.089299
500	0.351709	8.255283	8.441008
500	0.351709	8.422057	8.792717
500	0.351709	8.688894	9.144425
500	0.351709	9.189214	9.496134
500	0.351709	9.539439	9.847843
500	0.351709	9.856308	10.19955
500	0.351709	10.08979	10.55126
500	0.351709	10.57343	10.90297
500	0.351709	10.59011	11.25468
500	0.351709	10.92366	11.60639
500	0.351709	11.17382	11.95809
500	0.351709	11.57407	12.3098
500	0.351709	11.84091	12.66151
500	0.351709	12.22449	13.01322
500	0.351709	12.42462	13.36493

500	0.351709	48.23087	13.71664
500	0.351709	49.78186	14.06835
500	0.351709	51.86653	14.42006
500	0.351709	54.20136	14.77176
500	0.351709	56.78634	15.12347
500	0.351709	57.28666	15.47518
500	0.351709	59.20456	15.82689
500	0.351709	60.7889	16.1786
500	0.351709	62.79019	16.53031
500	0.351709	64.70808	16.88202
500	0.351709	66.79275	17.23372
500	0.351709	68.87741	17.58543

20000	14.06835	25.93326396	548.6655
20000	14.06835	26.51697086	562.7339
20000	14.06835	27.18406447	576.8022
20000	14.06835	27.76777137	590.8706
20000	14.06835	28.43486498	604.9389
20000	14.06835	29.10195859	619.0072
20000	14.06835	29.80240687	633.0756
20000	14.06835	30.3527591	647.1439

500	0.351709	12.92494	13.71664
500	0.351709	13.35855	14.06835
500	0.351709	13.80884	14.42006
500	0.351709	14.50929	14.77176
500	0.351709	14.85951	15.12347
500	0.351709	15.07632	15.47518
500	0.351709	15.42654	15.82689
500	0.351709	15.89351	16.1786
500	0.351709	16.09363	16.53031
500	0.351709	16.32712	16.88202
500	0.351709	16.69402	17.23372
500	0.351709	17.01089	17.58543
500	0.351709	17.34443	17.93714
500	0.351709	17.76137	18.28885
500	0.351709	18.1783	18.64056
500	0.351709	18.67862	18.99227
500	0.351709	18.92878	19.34398
500	0.351709	19.22897	19.69569
500	0.351709	19.5792	20.04739
500	0.351709	20.09619	20.3991
500	0.351709	20.44642	20.75081
500	0.351709	20.72993	21.10252
500	0.351709	21.08016	21.45423
500	0.351709	21.43038	21.80594
500	0.351709	21.76393	22.15765
500	0.351709	22.0808	22.50935
500	0.351709	22.49773	22.86106
500	0.351709	22.94802	23.21277
500	0.351709	23.41499	23.56448
500	0.351709	23.81524	23.91619
500	0.351709	24.19882	24.2679
500	0.351709	24.48234	24.61961
500	0.351709	24.76585	24.97132
500	0.351709	25.14943	25.32302
500	0.351709	25.69978	25.67473
500	0.351709	26.16675	26.02644
500	0.351709	26.60036	26.37815
500	0.351709	26.98394	26.72986
500	0.351709	27.36752	27.08157
500	0.351709	27.66771	27.43328
500	0.351709	28.08464	27.78498
500	0.351709	28.4849	28.13669
500	0.351709	28.90183	28.4884
500	0.351709	29.26873	28.84011
500	0.351709	29.7357	29.19182
500	0.351709	30.18599	29.54353
500	0.351709	30.60292	29.89524

500	0.351709	31.03653	30.24695
500	0.351709	31.32004	30.59865
500	0.351709	31.70362	30.95036
500	0.351709	32.52081	31.30207
500	0.351709	32.85436	31.65378
500	0.351709	33.50478	32.00549
500	0.351709	33.855	32.3572
500	0.351709	34.25526	32.70891
500	0.351709	34.82229	33.06061
500	0.351709	35.13916	33.41232
500	0.351709	35.58944	33.76403
500	0.351709	36.15647	34.11574
500	0.351709	36.5067	34.46745
500	0.351709	36.94031	34.81916
500	0.351709	37.49066	35.17087
500	0.351709	38.54133	35.52258
500	0.351709	39.05833	35.87428
500	0.351709	39.50862	36.22599
500	0.351709	39.95891	36.5777
500	0.351709	40.57597	36.92941
500	0.351709	41.07629	37.28112
500	0.351709	41.52658	37.63283
500	0.351709	42.06025	37.98454
500	0.351709	42.52722	38.33624
500	0.351709	42.94415	38.68795
500	0.351709	43.4945	39.03966
500	0.351709	44.02818	39.39137
500	0.351709	44.57853	39.74308
500	0.351709	45.09553	40.09479
500	0.351709	45.54582	40.4465
500	0.351709	46.06281	40.79821
500	0.351709	46.62984	41.14991
500	0.351709	48.04742	41.50162
500	0.351709	48.59777	41.85333
500	0.351709	49.03138	42.20504
500	0.351709	49.49835	42.55675
500	0.351709	50.11541	42.90846
500	0.351709	50.6324	43.26017
500	0.351709	51.18276	43.61187
500	0.351709	51.68308	43.96358
500	0.351709	52.10001	44.31529
500	0.351709	52.60033	44.667
500	0.351709	53.13401	45.01871
500	0.351709	53.58429	45.37042
500	0.351709	53.9512	45.72213
500	0.351709	55.36877	46.07383
500	0.351709	55.90244	46.42554

500	0.351709	56.53618	46.77725
500	0.351709	56.95312	47.12896
500	0.351709	57.62021	47.48067
500	0.351709	58.37069	47.83238
500	0.351709	58.8043	48.18409
500	0.351709	59.30462	48.5358
500	0.351709	59.87165	48.8875
500	0.351709	60.45536	49.23921
500	0.351709	60.939	49.59092
500	0.351709	61.63945	49.94263
500	0.351709	62.08974	50.29434
500	0.351709	62.72348	50.64605
500	0.351709	63.12373	50.99776
500	0.351709	63.9576	51.34946
500	0.351709	64.52463	51.70117
500	0.351709	65.25843	52.05288
500	0.351709	65.84214	52.40459
500	0.351709	66.37581	52.7563
500	0.351709	66.90949	53.10801
500	0.351709	67.65997	53.45972
500	0.351709	68.21032	53.81143
500	0.351709	68.97748	54.16313
500	0.351709	69.77799	54.51484
500	0.351709	70.49512	54.86655
500	0.351709	70.94541	55.21826
500	0.351709	71.37902	55.56997
500	0.351709	72.29627	55.92168
500	0.351709	73.13014	56.27339
500	0.351709	73.46368	56.62509
500	0.351709	74.04739	56.9768
500	0.351709	74.83123	57.32851
500	0.351709	75.13142	57.68022
500	0.351709	76.04867	58.03193
500	0.351709	76.79915	58.38364
500	0.351709	77.38286	58.73535
500	0.351709	77.96657	59.08706
500	0.351709	78.6003	59.43876
500	0.351709	79.38414	59.79047
500	0.351709	80.13462	60.14218
500	0.351709	80.71833	60.49389
500	0.351709	81.55219	60.8456
500	0.351709	82.38606	61.19731
500	0.351709	82.88638	61.54902
500	0.351709	83.72025	61.90072

10/25/08 Waterford aged asphalt and concrete
Inner ring 16.75 in in diameter
Area 1421.631
Phase 2 - Falling head experiment

Infiltrometer 7		Infiltrometer 8		Infiltrometer 9	
Water		Water	No falling h	Water	Loss due tc
Time (min)	Head	Time (min)	Head	Time (min)	Head
0	30			0	30
6.170616	28.7			4.92	27
14.17574	27			12.26	21.5
25.6831	25.2			16.01025	19.9
41.69335	23.2			21.01345	16.5
65.70872	20.8			26.01665	13.4
79.21737	18.7			31.01985	11.5
93.89343	17			36.02305	9.8
113.7395	15.5			41.02626	7.8
129.2494	14.5			46.02946	6.1
152.0973	12.7			51.03266	5
177.03	11			57.0365	3.5
205.2981	9			68.04355	2
268.3384	5.7				

10/25/08 Waterford aged asphalt and concrete
Inner ring 16.75 in in diameter
Area 1421.631 cm2
Phase 3 - Constant head experiment

Infiltrometer 7
Tomato juice

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	0
500	0.351709	30.01921	0.351709
650	0.457221	64.04099	0.80893
500	0.351709	87.05572	1.160639
375	0.263781	115.574	1.42442
1200	0.844101	203.6303	2.268521
500	0.351709	239.6534	2.62023
500	0.351709	266.6707	2.971938

Infiltrometer 8
Tomato juice

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	0
20000	14.06835	1.167413812	14.06835
20000	14.06835	2.584987725	28.13669
20000	14.06835	4.002561639	42.20504
20000	14.06835	5.420135553	56.27339
20000	14.06835	6.754322767	70.34173
20000	14.06835	8.171896681	84.41008
20000	14.06835	9.672857295	98.47843
20000	14.06835	11.09043121	112.5468
20000	14.06835	12.50800512	126.6151
20000	14.06835	13.92557904	140.6835
20000	14.06835	15.34315295	154.7518
20000	14.06835	16.67734016	168.8202
20000	14.06835	18.09491408	182.8885
20000	14.06835	19.42910129	196.9569
20000	14.06835	20.93006191	211.0252
20000	14.06835	22.18086242	225.0935
20000	14.06835	23.51504963	239.1619
20000	14.06835	24.93262355	253.2302
20000	14.06835	26.26681076	267.2986
20000	14.06835	27.55096595	281.3669
20000	14.06835	28.93518519	295.4353
20000	14.06835	30.0192123	309.5036
20000	14.06835	31.27001281	323.572
20000	14.06835	32.52081332	337.6403
20000	14.06835	33.68822713	351.7087
20000	14.06835	34.93902764	365.777
20000	14.06835	36.10644146	379.8454
20000	14.06835	37.22382325	393.9137
20000	14.06835	38.35788238	407.9821
		0	0
500	0.351709	15.92685986	0.351709
500	0.351709	49.94863379	0.703417
500	0.351709	71.96272281	1.055126

Infiltrometer 9
Tomato juice

Volume (cr	Depth (cm)	Time (min)	Cumulative depth
		0	0
500	0.351709	14.25913	0.351709
500	0.351709	21.51377	0.703417
750	0.527563	40.52594	1.23098
1500	1.055126	82.30267	2.286106
500	0.351709	101.8152	2.637815
900	0.633076	129.8331	3.270891
2825	1.987154	215.8882	5.258045
2325	1.635445	252.9119	6.89349
800	0.562734	286.9336	7.456224

500	0.351709	98.47969367	1.406835
500	0.351709	126.4976251	1.758543
1000	0.703417	156.0165172	2.461961
500	0.351709	177.2801259	2.813669
775	0.545148	204.0472569	3.358818
3500	2.461961	289.1016917	5.820778
2000	1.406835	325.1247465	7.227613
1750	1.23098	360.1471608	8.458593

CATI
CALIFORNIA AGRICULTURAL TECHNOLOGY INSTITUTE

MEMO

Date: January 20, 2009

To: Sonya Harrigfeld, Director
Dept. of Environmental Resources, Stanislaus County

From: Dr. Sajeemas (Mint) Pasakdee, Soil Scientist/Agronomist
California Agricultural Technology Institute (CATI),
California State University, Fresno
Nat Dellavalle, CPAg/SS, Principal, Dellavalle Laboratory Inc.

CC: Joe Bezerra, CATI Director of Operations, California State University, Fresno
Dr. Horacio Ferriz, Department of Physics, Physical Sciences, and Geology, California State University, Stanislaus
Martin Reyes, Stanislaus County Food Processing By-Products Re-Use Committee
William J. Lyons, Jr., Mape's Ranches & Lyons' Investments
James Mortensen, Superintendent, Del Monte Foods-Plant No. 1

Subject: Bench scale studies of peach by-products applied at various loading rates

Thank you for the continuing confidence of Stanislaus County in the work of the Research Team to fully address the matters raised by the Central Valley Regional Water Quality Control Board (CVRWQCB). As you know, the research team developed "Recommendations for Further Studies" in its Technical Review of the Stanislaus County Program (page 16), submitted to the CVRWQCB in April 2007. Contingent on funding, we are able to complete one of research tasks to Address Finding 9.a. under the Workplan approved by CVWQCB dated August 31, 2006. Our goal is to identify site and waste characteristics and conditions that would prohibit the application of food processing by-products to land. It would be desirable to establish the appropriate application rates of by-products based on agronomic loading rates such as plant nutrient and salinity factors, and utilizing tests that analyze characteristics of semi-solid and solid by-products.

The objectives of this soil-byproduct mixture bench scale study were as follows:

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ATTACHMENT C

1. To address Finding 9a (3) as part of the Task 7 proposed in the Technical Review of the Stanislaus County Program (page 16), submitted to the CVRWQCB in April 2007. (Notes: Task 7—"*Identify site and waste characteristics and conditions that would prohibit the application of food processing by-products to land. It would be desirable to establish the appropriate application rates of by-products base on salinity loading factors rather than focus on wastewater terms.*"
2. To quantify plant nutrient release (macro- and micronutrient and trace elements) and soil chemical properties from the soil-byproduct mixture decomposition at various application rates at 0, 7, and 30 days after land application, and
3. To establish potential maximum loading rate of peach by-products application on two soil types in Stanislaus County.

<u>Research Methodology:</u> We conducted bench scale experiments under controlled conditions at the CSU Fresno Greenhouse facility in September 2007. The range of air temperatures was observed between 74.1 and 93.3 °F during this study. We collected two soil types (sandy loam and silt loam) from sites not yet having received by-products in Stanislaus County (but are potential future application sites). Each soil type received three rates of by-products [9.8, 29.4, and 49 tons per acre (dry weight)] with a total of four replications under randomized complete block design. We prepared a total of 96 six-inch pots. The fresh weight of soil and by-product mixtures from various treatments is shown on Table 1. Then, these soil and by-product mixtures were incubated for periods of 1, 7, and 30 days prior to an analysis where the whole pot was collected and submitted to an analytical laboratory certified by the Environmental Laboratory Accreditation Program (ELAP).

We compared three application rates of peach by-products to a control (no by-product application). The current loading rate under Stanislaus County Food Processing By-product Land-application Program is approximately one truckload or 9.8 tons per acre or 1X thereafter. We also included three truckloads (3X) or 29.4 tons per acre, and five truckloads (5X) or 49 tons per acre. Flesh and liquid of the peach by-products were homogenized for an even application rate. In addition, the ratio of the fruit pit weight to the slurry weight was also considered at each application (Table 1). Each soil type was mixed and weighed at ~500 gm dry soil per pot. This weight was estimated based on an application rate of by-products per square inch at six inches depth with the soil bulk density at 1.4 Mg m^{-3}.

<u>Results and Discussion:</u> The actual fresh weight of soil and by-product mixtures collected during this study is shown on Table 1. *The loading rate* for various plant nutrients (dry weight basis) with peach by-products applied at 1X, 3X, and 5X rates are shown in Table 2. We observed saturated soil conditions from 5X treatments on both soils during the first 24-hour period, however, these conditions diminished after 3 days (Figures 1) as evaporation occurred. *The amount of water* contributed by an application of peach by-products at 1X, 3X, and 5X rates were equivalent to 0.63, 1.90, and 3.15 inches of irrigation water, respectively.

For *nitrogen application* in the case of existing dairies, the CVRWQCB has recognized and accepted an efficiency factor of 1.65 or 61% for the Whole Farm Nitrogen Balance in its General Order. Following this example, the amount of nutrients applied from peach by-products can be up to 1.65 times the amount harvested. When alfalfa is planted on sites receiving peach by-products, harvest alfalfa at 9 tons/acre can remove up to 600 lbs N/acre in Stanislaus County (Pasakdee and Dellavalle 2008). Applications of peach by-products at various rates will significantly substitute for the use of N fertilizer on these sites. Based on the 1.65 factor, according to the Dairy Order issued by the CVRWQCB, up to 990 lbs N/acre (1.65 multiplied by 600) of peach by-products can be applied to site planted with alfalfa. Our study showed the 1X (238 lbs N/A) and 3X (714 lbs N/A) loading rates of by-products containing 1.22% total N (dry weight) can be applied on these sites and water quality will be protected under accepted best management farming practices (Table 1).

Soil *nitrate-nitrogen (NO_3-N) and ammonium-nitrogen (NH_4-N)* concentrations from these sites significantly changed after by-product application (Tables 3 and 4). Applications of by-products at all rates on both soils encouraged soil N immobilization and denitrification processes (diminishing levels of soil NO_3-N) and soil ammonification (rising levels of soil NH_4-N) processes at 7 and 30 days after by-product application. The greatest immobilized rate occurred from 5X followed by 3X and 1X loading rates, respectively, and with a greater extent from sandy loam soil. The soil NO_3-N concentrations of sandy loam soil were significantly higher than silt loam soil. This may be because sandy loam soil was collected from sites containing greater soil microbial activities from decomposing grass stubbles, whereas silt loam soil was collected from a fallow field. Soil NH_4-N concentrations were slightly increased with applications of by-products at 1X, 3X, and 5X, respectively for sandy loam soil, whereas no significant change was observed for silt loam soil. The ranges of total soil N concentrations were from 4.2 to 4.4 g/kg and from 1.4 to 2.0 g/kg for sandy loam soil and silt loam soil, respectively.

We observed immobilization of nitrogen for up to 30 days following the application of by-products at all rates. The soil NO_3-N is a plant-available form of nitrogen while soil NH_4-N will ultimately be transformed to soil NO_3-N by soil microbial activity. This allows time for pre-irrigation and possibly the first crop irrigation for mineralization of soil organic nitrogen to produce soil NO_3-N. A longer incubation period is needed to determine the release rate of plant- available nitrogen.

Soil *phosphorous (P)* levels in both soils were reported as sodium bicarbonate extractable orthophosphate (PO_4-P) (Tables 3 and 4). Overall, applications of by-products at 3X and 5X significantly increased soil P concentrations in both soils with no significant difference between control soil and 1X loading rate of by-products. When alfalfa is planted on sites receiving 1X loading rate of by-products, the crop removal rate of P is slightly greater than that input from by-products (Pasakdee and Dellavalle 2008). For sandy loam soil, growers may need additional P fertilizer to grow alfalfa with by-products applications at 1X, but an application rate of peach by-products greater than 3X will provide adequate P to fulfill crop P removal rate by alfalfa and substitute the need for additional P fertilizer. For silt loam, the control soil contained adequate levels of P to grow alfalfa. By-product application to this soil will help to maintain optimum level of soil P reservoir.

Overall, applications of by-products at all loading rates significantly increased soil *potassium (K)* concentrations in both soils, more for sandy loam soil than silt loam soil (Tables 3 and 4). Application of K fertilizer is often recommended for alfalfa growers in California (Hays 1998) and especially when soil K concentration is below 80 mg/Kg (UC). Harvesting 9 tons/acre of alfalfa will remove up to 425 lbs K/acre. An application of by-products to these soils is necessary to sustain levels of soil K over time especially for alfalfa production where a single application of by-products is only applied at pre-plant, and harvesting alfalfa continues over three to five years.

Applications of by-products at all rates significantly reduced *soil pH* levels at day 0 but these differences were no longer apparent by 30 days (Tables 3 and 4). In addition, soil pH of soil-by-product mixtures were between 6.4 and 6.9, which is considered an optimal range for farming because the majority of essential plant nutrients become available for plant uptake. Alkaline soil would benefit from application of peach products or acidic by-products because their soil pH levels will be lowered to encourage a greater plant nutrient availability.

Soil electrical conductivity (EC) levels were significantly increased with by-product application in both soils, at the greater extent on silt loam soil than sandy loam soil (Tables 3 and 4). Additional K, Mg, Ca, and Na from by-product application resulted in rising soil EC levels, which is expected from application of plant-based soil amendments. Although the concentrations of sodium (Na) in these soils were increased with by-product applications, the difference with respect to the control soil was comparatively small (<10%) for 1X and 3X loading rates (Tables 3 and 4). The application rates at 1X, 3X, and 5X loading rates will contribute ~10, 30, and 50 lbs Na/acre to these soils, respectively (Table 1). An annual harvest of alfalfa removed about 16 Na/acre while the wheat-silage corn rotation removed about 6 lbs Na/acre (Pasakdee and Dellavalle 2008). In general, one-acre foot of good quality irrigation water with EC ~1 dS/m may deliver up to 2,000 lbs of salt per acre (UC). If Na content in this irrigation is ~10 meq/L, this irrigation water will transport ~627 lbs of Na per acre, and when comparing to Na contribution to these soils from by-product application, these amounts are de minimis.

Applications of peach by-products at all loading rates to both types of soils significantly increased other plant micronutrients such as calcium (Ca), magnesium (Mg), zinc (Zn), and manganese (Mn), but no significant change to levels of copper (Cu), iron (Fe), and boron (B) was observed (Tables 3 and 4). The concentrations of Ca, Mg, Zn, Mn, Cu, Fe and B obtained from the 5X loading rate to these soils were within or below average background soil concentrations reported in California (Chang and Page 2000). Growers will benefit from additional micronutrients to these soils by utilizing these by-products as soil amendments prior to planting crops.

Conclusions:

The application of peach by-products significantly increased macro- and micronutrients, and trace elements to sandy loam and silt loam soils, which are the potential sites for future by-product applications. The diminished levels of soil nitrate from a land-application event for up to 30 days may provide ground water protection during the period when pre-irrigation could cause nitrate leaching loss. In general, contribution of salt from by-products is minimal. Growing forage crops such as alfalfa or silage corn on these sites will remove significant amounts of these elements without posing risk to ground water quality from applications of by-products. However, other factors that may cause nutrient leaching or runoff may increase risk of ground water contamination which is beyond the scope of this research project. Growers are expected to benefit economically from a reduction in the use of chemical fertilizer inputs because they are replaced by applications of less-expensive by-products. Considering annual elemental inputs from by-products, harvest crop removal rate, crop selection and irrigation management, and proper site management, applications of by-products on these farmlands will pose minimal impacts to ground water quality.

References

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Figure 1. Conditions of soil-byproduct mixtures at various rates (clockwise: control (0), 1X, 3X, and 5X) after incubation for 0 day (left) and 30 days (right)

Table 1. Fresh weight of soil and peach by-product mixtures at various rates applied to sandy loam and silt loam soils collected at day 0, 7, and 30 for chemical analysis during this study.

Treatments:	Application Rates of Peach By-products (Fresh weight in grams per pot)			Soil Type (Dry weight in grams per pot)
	Solid/Semi-Solid	*Peach Pit*	*Total*	Sandy Loam or Silt Loam
Control	0	0	0	500
1X	58	5	63	500
3X	173	15	188	500
5X	289	25	314	500

Table 2. Peach by-products at various rates applied to sandy loam and silt loam soils during this study.

	Peach By-products Dry weight basis[a]	Constituent Loading		
		9.8 tons/A (DW) 1X (lbs/A)	29.4 tons/A (DW) 3X (lbs/A)	49 tons/A (DW) 5X (lbs/A)
Moisture (%)	**87.95**	0.63[b]	1.9[b]	3.15[b]
pH	**4.13**	NA	NA	NA
EC (mmhos/cm)	7.78	NA	NA	NA
TS (mg/L)	18,983	NA	NA	NA
TVS (mg/L)	23,433	NA	NA	NA
Organic Matter (%)	97.18	18,950	56,850	94,750
Ash (%)	2.82	550	1,650	2,749
Total N (%)	**1.22**	**238**	**714**	**1,189**
Total C (%)	6.77	1,320	3,960	6,601
Total P (%)	**0.12**	**23**	**70**	**117**
P_2O_5 (%)	0.27	53	158	263
Total K (%)	**0.85**	**166**	**497**	**829**
K_2O (%)	1.02	199	597	994
S (%)	0.05	10	29	49
Na (%)	0.05	10	29	49
Cl (%)	0.07	14	41	68
C:N	46	NA	NA	NA
Ca (%)	0.25	49	146	244
Mg (%)	0.08	16	47	78
Fe (mg/kg)	91.23	1.78	5.34	8.89
Cu (mg/kg)	8.27	0.16	0.48	0.81
Mn (mg/kg)	8.83	0.17	0.52	0.86
Zn (mg/kg)	30.80	0.60	1.80	3.00
As (mg/kg)	<0.01	NA	NA	NA
Cd (mg/kg)	0.03	0.001	0.002	0.003
Cr (mg/kg)	0.45	0.009	0.026	0.044
Pb (mg/kg)	<0.01	NA	NA	NA
Mo (mg/kg)	0.45	NA	NA	NA
Ni (mg/kg)	0.71	0.014	0.042	0.069
Se (mg/kg)	0.27	0.005	0.016	0.026
Pb (mg/kg)	<0.014	NA	NA	NA

[a]The unit of each constituent is in parenthesis.

[b]Irrigation water unit is in acre inches.

Table 3. Sandy loam soil properties changed at 0, 7, and 30 days after peach by-products applied at various rates

	Control			1X			3X			5X		
	Day 0	Day 7	Day 30	Day 0	Day 7	Day 30	Day 0	Day 7	Day 30	Day 0	Day 7	Day 30
pH	6.7 abcd	6.4 cd	6.3 d	5.6 e	6.5 bcd	6.8 abc	5.2 ef	6.3 d	6.9 ab	5.1 f	6.4 cd	6.9 ab
EC (dS/m)	1.4 d	1.7 d	2.1 cd	3.3 bc	2.1 cd	3.0 bc	5.7 a	3.6 b	3.4 b	6.1 a	4.2 b	3.4 b
Ca (meq/L)	5.5 e	6.6 e	8.2 de	15.7 b	9.7 cde	13.8 bc	24.2 a	15.0 b	12.8 bcd	23.3 a	14.5 bc	10.0 cde
Mg (meq/L)	3.7 ef	4.5 ef	9.2 bc	10.1 bc	6.5 cde	5.3 def	15.1 a	10.3 b	8.2 bcd	14.7 a	10.6 b	6.5 def
Na (meq/L)	2.3 e	2.5 e	3.2 cde	2.9 de	3.1 cde	4.1 bc	3.7 bcd	4.2 b	5.3 a	3.9 bcd	4.4 ab	5.2 a
NO_3-N (mg/kg)	76 b	89 a	89 a	32 c	40 d	32 d	15 e	11 ef	15 e	8 f	5 f	8 f
NH_4-N (mg/kg)	8 b	8 b	6 b	6 b	11 b	8 b	14 b	9 b	17 b	35 ab	41 a	47 a
PO_4-P (mg/kg)	33 f	27 f	26 f	48 d	33 f	30 f	74 b	42 de	40 e	90 a	61 c	57 c
K (mg/kg)	257 d	285 d	240 d	417 c	384 c	374 c	674 b	664 b	654 b	870 a	935 a	878 a
Zn (mg/kg)	3.1 d	3.4 cd	3.2 d	3.6 bcd	3.8 bc	3.4 cd	4.1 b	3.9 bc	3.4 cd	5.0 a	4.9 a	3.7 bcd
Mn (mg/kg)	26 e	23 e	22 e	62 b	40 cd	34 d	71 a	49 c	42 cd	71 a	73 a	48 c
Cu (mg/kg)	0.7 a	0.8 a	0.8 a	0.8 a	1.0 a	0.8 a	0.9 a	0.8 a	0.8 a	0.9 a	0.9 a	0.8 a
Fe (mg/kg)	119 b	122 b	128 b	134 b	137 b	117 b	145 b	151 ab	115 b	160 ab	211 a	144 b

[a]Each number represents mean values based on four replications.
[b]Values in a row followed by the same letter are not significantly different, *P< 0.05*, using Tukey-Kramer multiple-comparison test.

Table 4. Silt loam soil properties changed at 0, 7, and 30 days after peach by-products applied at various rates

	Control			1X			3X			5X		
	Day 0	Day 7	Day 30	Day 0	Day 7	Day 30	Day 0	Day 7	Day 30	Day 0	Day 7	Day 30
pH	7.2 a	7.1 a	7.3 a	6.5 b	6.4 b	6.6 b	6.0 c	6.4 b	6.4 b	5.6 d	6.4 b	6.4 b
EC (dS/m)	2.3 f	3.2 ef	4.6 de	5.6 bc	4.7 de	6.2 bcd	9.5 a	6.4 b	9.2 a	9.2 a	6.4 b	9.5 a
Ca (meq/L)	5.6 e	7.3 e	11.0 de	19.0 bc	15.2 cd	19.2 bc	34.6 a	22.6 b	32.8 a	34.2 a	23.6 b	30.1 a
Mg (meq/L)	4.6 f	6.3 f	9.3 ef	15.4 cd	12.8 de	16.0 cd	27.1 a	18.5 c	26.8 a	26.7 a	20.0 bc	25.1 ab
Na (meq/L)	11.4 d	15.1 cd	21.2 bcd	17.1 bc	18.8 bc	22.6 bc	20.5 bc	22.0 bc	28.0 ab	18.1 bc	21.1 bc	35.1 a
NO_3-N (mg/kg)	22 a	23 a	22 a	18 b	11 c	8 d	5 de	3 ef	1 f	3 ef	2 f	1 f
NH_4-N (mg/kg)	4 bc	8 bc	5 bc	<0.1 c	6 bc	4 bc	1 c	4 bc	4 bc	15 a	6 bc	10 ab
PO_4-P (mg/kg)	71 d	64 ef	59 f	76 cd	63 ef	62 ef	85 b	69 de	69 de	97 a	80 bc	75 cd
K (mg/kg)	244 de	248 de	216 e	269 d	273 d	253 de	338 c	363 c	327 c	446 a	415 ab	378 bc
Zn (mg/kg)	1.2 b	1.1 b	1.0 b	1.4 a	1.1 b	1.2 b	1.5 a	1.2 b	1.2 b	1.8 a	1.4 a	1.3 a
Mn (mg/kg)	17 e	18 e	21 e	55 de	47 de	51 de	119 b	74 cd	70 cd	171 a	184 a	106 bc
Cu (mg/kg)	1.9 b	1.9 b	2.0 b	2.0 b	1.9 b	2.0 b	2.2 b	1.8 b	2.0 b	2.2 bc	2.0 b	3.1 a
Fe (mg/kg)	31 f	28 f	28 f	37 de	29 f	32 ef	50 b	37 de	38 de	60 a	47 bc	42 cd

[a]Each number represents mean values based on four replications.
[b]Values in a row followed by the same letter are not significantly different, $P<0.05$, using Tukey-Kramer multiple-comparison test.

Nutrient Management Plan for the Use of Food Processing By-Products as Soil Amendments

Introduction and Purpose

The purpose of this nutrient management plan (NMP) is to develop an operation plan for the reuse of solid, semi-solid and slurry food processing by-products (by-products) in a manner that minimizes potential negative impacts on soil and water quality through practical and available management practices and technologies. This will be accomplished by performing a detailed investigation of current site properties including location, acreage, crop nutrient removal rate, soil characteristics and irrigation practices. To ensure an application of by-products on farmlands that protects soil and water quality, developing the NMP is recommended to monitor and quantify the volume and composition of all nutrient inputs and outputs.

Agronomic rates and sampling protocols shall be established and approved by a Professional Soil Scientist certified by the SSSA Certification Board (formerly known as ARCPACS), a Certified Professional Agronomist (CPAg) certified by the American Society of Agronomy (ASA) Certification Board, (formerly known as ARCPACS) or a Certified Crop Advisor (CCA) certified by the California Certified Crop Advisor Board.

Facility Information

1. **Addenda from permit application**
    a. Site operator must contact Dept. of Environmental Resources, Stanislaus County to obtain current permit information in regards to the use of by-products as soil amendments on farmlands
2. **Plan of Operation Guidelines for Food Processing By-Product Use Sites**
    a. The Plan of Operation Guidelines for Food Processing By-Product Use is attached as *Appendix A*.
3. **Current crop map**
    a. Provide a crop map for the period to which this NMP applies that includes all items outlined in item 8 of the Plan of Operation Guidelines for Food Processing By-Product Use Sites document.

Nutrient and Irrigation Management

To optimize use of by-products as soil amendments, site operators must manage the application of by-products as a part of their soil fertility program. Site operators shall consult with county agricultural extension specialists, certified crop/soil consultants, or universities to ensure the effective use of by-products in their fertilizer and irrigation practices. Establishment of proper

ATTACHMENT D

sampling methods is integral to creating an accurate Nutrient Management Plan. The technical standards for NMP are as follows:

Technical Standards for Nutrient Management

I. Sampling Requirements

1. Soil
   a. Prior to the land application event analyze soil samples at a minimum as stated on *Appendix B.*
   b. Pre-Plant/Post-Harvest Soil Samples
      i) Each year following the final harvest for the crop year, analyze soils in the same way as for the pre-application analysis.
      ii) The post-harvest analysis for one crop may fulfill the requirement for the pre-harvest analysis for the subsequent crop in the same field.
   c. Methods and Reporting
      i) Soil samples shall be drawn from 1-foot intervals to the rooting depth. Alternative sampling intervals may be employed with technical justification. Each field scheduled to receive by-products in any given year should be sampled in late spring or early summer prior to the by-products application. Obtaining representative samples is critical to getting valid and interpretable analytical results. One method to ensure representative samples are collected is to conduct the soil sampling as follows. Collect soil samples from the depth intervals of 0-12 inches, 12-24 inches, and 24-36 inches at 10 to 20 sites per field based on geostatistical-based standards of practice. Mix samples taken from the same depth intervals to form a single composite sample for that depth interval. This composite sample should have a minimum weight of one pound. Submit each composite sample to a certified laboratory for analysis, for a total of three composite samples per field representing the three depths.

2. By-Products
   a. Prior to the land application event analyze by-product samples at a minimum as stated on *Appendix B.*
   b. Methods and Reporting
      i) Samples shall cover each type from each source of by-products that are to be land-applied. Composite samples shall be collected prior to land application. Container labeling for each plastic bottle shall include load number, field/site number, type of by-products, and date.

3. Plant Tissue
   a. Crop Removal Analysis (CRA)
   i) At minimum, plant tissue samples of the harvested portion shall be tested for total Kjeldahl N, P, K, Mg, Ca, Na, Cl and moisture.
   b. Mid-Season Tissue Analysis (as needed)

i) Plant tissue sample may be collected during the growing season to monitor crop nutrient status and to determine whether additional nutrient application is needed. The samples will be analyzed for nitrogen, phosphorus and potassium.

c. Methods and Reporting

i) For CRA collect samples of the harvested portion at 10 to 20 locations per field following geostatistical-based standards of practice. Mix samples taken from the same site to form a single composite sample. Samples may be collected from hay bales using a hay sampler in the same manner to obtain representative samples. This composite sample should have a minimum weight of 1 lb. Submit each composite sample to a certified laboratory for analysis. Collect a minimum of one CRA sample for each harvest from each field.

ii) For Mid-Season Tissue Analysis use sampling protocols specified by the University of California Cooperative Extension or by the Western Fertilizer Handbook or by a certified crop advisor, agronomist or soil scientist.

4. Fertilizer (as allowed, see II.2)
   a. The guaranteed analysis for the N, P, and K content of any additional fertilizer added to a land application area must be included in the whole farm budget.

5. Irrigation Water
   a. Analysis Recommended

      i) Each year, during one irrigation event for each source, then analyze for: electrical conductivity (EC) and nitrate-nitrogen. If available, irrigation district data may be used.

II. Crop Requirements

1. Realistic yield goals for each crop in each land application area shall be projected based on previous yield history. If projected yield is different than historical yields, explain the discrepancy. For new crops or varieties, industry or Stanislaus County Agricultural Crop Annual Report or university yield estimates may be used until documented yield information is available.
2. Rate of by-product use shall be based on crop removal analysis and all other nutrient sources, and shall be authorized by a CCA. Site operators shall consult with county agricultural extension specialists or certified crop/soil consultants or universities to determine how much fertilizer replacement value can be expected from by-products. This can help the grower avoid over-fertilizing their crops, thereby maintaining optimum crop production and protecting soil and water quality.

III. Available Nutrients

1. All sources of nutrients available for each crop in each land application area shall be identified prior to land applications. Potential nutrient sources include, but are not limited to, by-products, commercial fertilizers, soil, soil amendment (i.e., compost, manure), irrigation water, atmospheric deposition and previous crop residues.
   a. Nutrient content of soil, by-products, and irrigation water shall be determined based on laboratory analysis (see *Appendix B*).

b. Annual Nitrogen Deposition Rate from atmosphere is estimated at 14 lbs Nitrogen/acre (Managing Dairy Manure in the Central Valley of California, UC, Division of ANR, Committee of Experts on Dairy Manure Management, June 2005, page 37).

IV. Nutrient Application Rates

1. Application rates shall be based on agronomic rates.
2. Currently no maximum loading rate has been established. By-product application shall therefore be limited by salt loading rates, agronomic nitrogen loading rates, or a rate that will prevent soil saturation with water.
3. In January, 2012 agronomic nitrogen loading rates shall be defined as a whole farm nitrogen balance not exceeding 1.4 unless authorized by a CCA (see table 1).

IV. Overall Nutrient Balance

1. Determine an annual nutrient budget. Nutrient inputs are from fertilizer, irrigation, soil amendments (by-products), soil carry over, atmospheric deposition, and other sources. Outputs of nutrients include biomass from all harvested crops/materials, leaching, runoff, volatilization, and denitrification. Maintaining records of by-product constituents is essential to determining the ability of by-products to provide nutrients to plants. These plant nutrients shall be accounted for as part of the total nutrient management program during the crop growing season.

Table 1: Whole Farm Nitrogen Balance

Whole Farm Nitrogen Balance								
Field Name	Total Nitrogen in Storage	Total Nitrogen Exported	Nitrogen Imported	Irrigation Nitrogen		Atmospheric Nitrogen	Total Nitrogen Removed by Crops (WF)	Field Nitrogen Balance
				Fertilizer	By-Products			
Example	73 lbs/ac	0	170lbs/ac	25.8 lbs/ac	12 lbs/acft	14 lbs/acyr	187 lbs/ac	**1.58**

The Whole Farm Nitrogen Balance is to be determined as the ratio of (total nitrogen in storage – total nitrogen exported + irrigation nitrogen + atmospheric nitrogen)/ (total nitrogen removed by crops). A value larger than 1.0 would indicate a theoretical excess of the nutrient. In practice, values between 1.0 and 1.5 are considered acceptable.

V. Nutrient Budget

1. The NMP shall include a nutrient budget that includes planned rates of nutrient applications for each crop, ensuring that these rates do not exceed the crop's requirements for total nitrogen considering all nutrient sources, climatic conditions, the irrigation schedule, and application.

Stanislaus County

Food Processing By-Products Use Program

Land Application
Direct Feed
Dehydration
Composting

Prepared by

Department of Environmental Resources

May 2006

Table of Contents

Welcome to Stanislaus County, we appreciate your contacting the Department of Environmental

Resources (DER or Department) to explore your interest in the land application, direct feed, composting and/or dehydration of food processing by-products. The DER has prepared this comprehensive guide to our program so you will understand what is expected of our applicants. Should you have questions that are not answered here, please contact our office at 525-6700 and ask for the solid By-Product unit.

A permit from the DER is required for any operator wanting to apply food-processing by-products to land, direct feed, composting and/or drying. A Plan of Operation, a performance bond, proof of required insurance coverage, and annual regular inspections by DER staff are also required.

The planned use of the by-products may trigger the CEQA environmental review process. The DER, as lead agency, will prepare an initial study based on information provided by the Applicant. The DER will determine whether the project may cause significant environmental impacts, and adopt the appropriate level of mitigation, if any.

Definitions:

Food processor: A processor of fruit, nut or vegetable raw products which may include but are not limited to tomato, peaches, almonds, walnuts, pears, grapes, raw olives, grain products or other raw plant material, i.e., canneries, nut processors, vegetable processors, frozen food processing, etc.

By-product: Food processing by-products are solid or semisolid substances derived from agricultural plant material delivered to a food processor for processing that are not utilized in the final product. Food processing by-products include but are not limited to culls, peelings, seeds, under or over ripe food, skins, cores, pomace, puree, hulls, shells, pits, stems, leaves and any substance including soil washed from plant produce.

Permit:

The permit application is the first step in being authorized to apply food processing by-products to land, direct feed, composting or dehydration in Stanislaus County. You are required to identify the proposed site and all the persons involved in the operation. The initial application fee, annually thereafter, is based on a weighted labor rate for staff time associated with the processing of your application, administering the program and enforcing the program will be billed to you by the Accounting unit.

- Permit approval process: The Department may grant a permit for food processing by-products use, upon application therefore whenever in the opinion of the Department the granting of such permit is in the public interest and welfare and in compliance with all applicable local, State and Federal regulations including any CEQA or other environmental reviews required by law.

- Permit appeal process: Should DER deny the permit application, an Applicant may appeal to the Board of Supervisors. Such appeal must be in writing and must be received by the clerk of the Board not more than fifteen days after denial of the permit. Appeals filed shall be accompanied with a fee in an amount set by resolution of the Board. The hearing on such appeals shall be after notice of the time thereof has been mailed to appellant at least seven days before the hearing. Any appeal not accompanied by the required fee within the fifteen-day period described above shall be deemed untimely. (Stanislaus County Refuse Ordinance 9.12.080)

- Permit renewal process: Permits may be renewed upon expiration thereof provided the department finds that the permit holder is capable of continuing operation in conformity with the provisions of the Stanislaus County Refuse Ordinance and the rules and regulations of DER.

Fees:

The permit holder shall reimburse the Department for all costs incurred by it in administering this permit, including, but not limited to, processing the permit application, enforcing the permit terms, and monitoring permitted activity at the permit location. The Department shall issue an invoice itemizing all costs incurred by the Department and the permit holder shall remit payment as shown in invoice within 30 days of the invoice date. All costs will be based on the current weighted labor rates of the appropriate Department Staff member. A late payment charge equal to 1.5 percent of the unpaid invoice amount shall accrue and shall be added to the total amount each month that an invoice payment is past due.

Sampling/Testing:

The following references (and all updated versions thereafter) may be used for methods analyses made pursuant to this: Soil, Plant and Water Reference Methods for the Western Region, 2003, 2nd Edition, 2003 and Test Methods for the Examination of Composting and Compost. 2002.

The Laboratory performing the analysis shall be certified by the California Department of Health Services in its Environmental Laboratory Accreditation Program and participate in the North American Proficiency Testing Program.

Agronomic rates shall be established by a Certified Professional Soil Scientist certified by the SSSA Certification Board (formerly known as ARCPACS), a Certified Professional Agronomist (CPAg) certified by the American Society of Agronomy (ASA) Certification Board, (formerly known as ARCPACS) or a Certified Crop Advisor certified by the California Certified Crop Advisor Board.

Performance Bond:

To further ensure compliance with program requirements, the permit holder shall submit a cash bond, certificate of deposit, irrevocable letter of credit, or a faithful performance bond in favor of the DER, in an amount equal to 125 percent of the estimated cost (as determined by the DER) for clean-up and remediation at the permit location. This shall occur at or before the time the permit is issued. If submitting a faithful performance bond, the applicant will be required to complete a performance bond form. For more information regarding this requirement, please contact the DER.

Insurance:

Provide a certificate of current insurance on all hauling vehicles: $1,000,000 GL, & $100,000 PD, minimum coverage extending through the permit period. Vehicle license numbers shall be indicated on the forms.

Site Inspections:

The DER will inspect the site(s) prior to issuing a permit to assure that requirements listed below are met. During the period when applications occur and for 24 days following the end of a season or termination of the program the DER will inspect the site(s) to assure that the permitee is adhering to conditions of the permit and Plan of Operation. Inspections will occur weekly or at other frequencies determined by the DER.

Vehicle Inspections & Hauler Requirements:

The DER must perform an annual inspection of vehicles collecting and/or transporting food processing by-products, and an identification sticker will be issued and shall be displayed on each vehicle. Prior to the beginning of the season, please contact the DER for inspection appointments. The following are checked during each inspection: leakproof beds/bodies, load covering, current vehicle registration, broom and shovel, fire extinguisher, operable brake lights and turn signals. At the time of inspection applicant must provide proof of certification/documentation that the hauler complies with the California Department of Business, Transportation and Housing B.I.T. Program, and that all drivers have a Class A License with prior endorsements from the Department of Motor Vehicles and the California Department of Transportation.

ALL APPLICANTS SHALL SUBMIT A "PLAN OF OPERATION"

In order for your Application and Plan of Operation to be considered COMPLETE, please answer all applicable questions on the following pages and provide all applicable information.

It may be necessary for you to provide additional information and/or meet with DER staff to discuss the application. Pre-application meetings are not required, but are highly recommended. An incomplete application will be placed on hold until all necessary information is provided to the satisfaction of the DER. An application will not be accepted or approved without all of the information identified being provided.

1. List the owner of the site. If different from the permit applicant, list the property owner's name, mailing address and phone number. If the parcel is under a different ownership, the project applicant must provide a notarized letter from the owner that states that applicant has the owner's consent to conduct the proposed project on that parcel and that the owner has approved the proposed plan of operation.

2. List the address and the assessor's parcel number(s) of the site.

3. List the general plan and zoning designation of the site.

4. List the current use of the site.

5. List the soil types of the project site. List their approximate absorption/water holding capacities.

6. List the approximate depth to groundwater at the site. State how the depth was determined, and the month and year the depth was determined.

7. Provide a vicinity map showing the location of the site and all proposed delivery routes.

8. Provide a plot plan drawn to a legible scale which clearly shows the intended project. The map must contain the following physical data:

- Sufficient description to define the location, date, north arrow, scale and boundaries; (full width of all public and private road ways bordering the property must be shown);
- Name and address of recorded owner(s);
- Name and address of person(s) preparing the map;
- Acreage to the nearest acre;
- Location and size of all waterways, drainage courses, pipelines, existing irrigation and drainage facilities, irrigation and drainage patterns, existing or proposed water wells, septic tanks and drainage (leach) fields, sewage lines and structures used in connecting therewith, slope of the land; and
- Outline of existing buildings and other structures to remain in place within the project area, showing the distance to existing or proposed public and private road ways.

9. Provide an 8½" x 11" reproducible, to scale, legible area map showing specific land uses (crops, houses, buildings, parcel lines and parcel sizes, etc.) for the adjacent two parcels in each direction from the subject property.

10. Provide a list of names, addresses and assessment numbers of all properties located within ¼ mile (1320 feet) and/or two parcels in each direction of applicant's project. Said information must be taken from the latest assessment roll of the subject county. A written notice of the permit application to operate a Food Processing By-Product Use Site will be sent by the applicant to those property owners located within ¼ mile (1320 feet) and/or two parcels in each direction of the subject site. The notice will include a description of your project approved by DER staff. Documentation of the notice must then be submitted to DER staff.

11. Name the site manager, provide a mailing address and list a 24-hour contact phone number.

12. List the types of by-product you plan to accept at the site, and describe how by-product will be ultimately utilized.

13. List the names, addresses, phone numbers and contact persons for the food processing plant(s) that will provide the by-product.

14. List the names, addresses, phone numbers and contact persons of the hauler(s) who will haul the by-product to you site.

15. State how many tons per day of by-product will be delivered to your site. List the total tons for the season.

16. If more than one type of by-product will be delivered, estimate the tons per day of each type of by-product that will be delivered to the site.

17. State how many truckloads per day will be delivered to your site.

18. Give the date that by-product deliveries will start and the date they will stop each season or indicate if you will accept the by-product year-round. Estimate how many days per year the site will accept by-product.

19. List the days of the week, and the approximate times that by-product will be delivered to your site.

20. Explain in a detailed, step-by-step manner, how you will use or process the by-products.

21. Explain in detail, the methodology to be used for tracking, receiving, storing, and depositing by-products. This tracking procedure must include records of when by-

product is received, where it is received, and the location of the by-product when it is used at the site.

22. List the types of the equipment you will use to manage the by-products. Indicate if that equipment is under your ownership. List stand-by equipment available in case of equipment breakdown.

23. Explain in detail how you will prevent the following conditions from occurring, and provide contingency plans in the event these conditions occur:

- Excessive liquid accumulation and excess moisture.
- Excessive dust.
- Excessive noise.
- Excessive objectionable odors.
- Excessive fly, mosquito and/or vector nuisance.
- Inclement weather.

24. Describe how the by-products will be contained on the site and not allowed to flow or otherwise be deposited on other surrounding properties or waterways.

25. Applicant shall provide DER staff with written verification from the food processing by-product processor, that all by-products deposited on permitted sites in Stanislaus County will not pose a risk to land, air, water, to human and animal health or the environment and that utilization of the by-product as direct feed or as a soil amendment is an acceptable use of said by-product.

26. Where applicable, the site operator shall demonstrate compliance with the Central Valley Regional Water Quality Control Board's Irrigated Lands Conditional Waiver Program (Resolution No. R5-2003-0105)

GENERAL PERMIT TERMS AND CONDITIONS

All operations (land application, direct feed, composting and/or dehydration) shall comply with the following terms and conditions:

1. Only the types and amounts of food processing by-product listed in the permit application and plan of operations may be received and used at the permit location.

2. The permit holder is prohibited from receiving milk, whey, cheese by-products, meat and animal by-products, including dead animals, as well as fruit and vegetable by products that, because of processing, contain high concentrations of agriculturally and environmentally deleterious salts or constituents that have no agronomic benefit.

3. The total amount of by-product delivered to the permit location shall not exceed the amounts stated in the approved plan of operation.

4. The permit holder shall maintain a daily log approved by the DER which shall contain the following information: (a) date and time of each delivery of material, (b) name of the hauler of the material, (c) amount (by weight) delivered, (d) source of material, and (e) type of material. All daily logs shall be submitted annually to the DER and shall be made available to the DER for review and inspection upon reasonable request of the DER.

5. Written procedures acceptable to DER shall be developed whereby food processing by-product trucks are directed to the correct discharge lanes/areas during all delivery times. These procedures shall be implemented whenever the site receives food processing by-products.

6. The site shall be operated and managed at all times so that no excessive objectionable food processing by-product odors migrate off-site, and no excessive insect, rodent or other nuisances or public health hazards are created.

7. Approved spray equipment, insecticides and pesticides shall be readily available for use at all times to control flies, mosquito's, gnats and other pests. All insecticides and pesticides used shall be stored and used according to the label directions and in compliance with applicable local, state and federal rules, regulations and laws.

8. Mechanical equipment shall be readily available and be adequate to perform the necessary by-product operations. Standby equipment must be readily available, in the event of mechanical failure. If no equipment is available or if equipment becomes inoperable, no by-product materials shall be accepted at the site until operable processing equipment is available and existing stockpile is processed.

9. To prevent surface water quality degradation, ensure that all site personnel are familiar with the proper use and function of any on-site water control structures, which allow discharge. Maintain all valves that allow runoff and repair immediately as needed.

10. The permit holder grants to the DER the right of access to the permit location for all reasons and purposes reasonably related to the administration of this permit by the DER, including, but not limited to the right to enter upon the permit location to remediate any problem related to the permitted activity.

11. The permit application and Plan of Operations and supplements or amendments thereto submitted by the permit holder to obtain this permit are incorporated herein by reference. The permitted activity shall be operated in conformance with the above documents, these permit conditions and all applicable state and local laws, ordinances, regulations and codes. In the event of any conflict between the permit application or the plan of operations and the permit conditions, the permit conditions shall take precedence. All supplements, amendments or changes to the Plan of Operation must be submitted in writing to the DER for review and approval prior to initiating said changes in the permitted activity. The issuance of this permit does not release the permit holder from responsibility to comply with the permitted activity.

12. The DER may modify the conditions of this permit for cause, after prior notification to the permit holder, to eliminate, reduce or ameliorate any condition or nuisance that adversely affects the public health, safety or welfare, or threatens to unreasonably degrade the quality of surface water or groundwater.

13. The provisions of this permit are intended to be severable and if any individual condition or provision hereof is held to be invalid by the order of the Board of Supervisors, by order of any court of competent jurisdiction or for any other reason, the remaining terms of this permit shall not be affected thereby; provided, however, the DER, in its sole discretion, may terminate this permit if it determines that the permit, as modified by the severance, no longer achieves the objectives of the DER or adequately protects the public health, safety and welfare.

14. This permit may be suspended or revoked by the DER for cause. This permit is granted on the condition that the person(s) named in the permit will comply strictly with the laws, ordinances, regulations, and any specific conditions that are now or may hereafter be in forced by the State of California, Stanislaus County and the DER in the incorporated or unincorporated areas of Stanislaus County pertaining to the above mentioned business.

Notice: Conditions may be added, deleted, or modified at the sole discretion the DER. The specific conditions of your permit are valid only for the permit period, and are subject to change.

LAND APPLICATION OPERATIONS SHALL ALSO COMPLY WITH THE FOLLOWING TERMS AND CONDITIONS

1. Prior to accepting food processing by-products at the site, the soil shall be prepared to receive by-products. Clods of soil shall be broken by a Schmeizer or equivalent. The soil surface shall be leveled to reduce pocket holes and furrows. Soil shall be sufficiently dry to retain moisture applied with food processing by-product in the surface 12 inches.

2. Food processing by-product shall be discharged from the trucks as thinly and evenly as practical. Overlapping onto previously spread food processing by-product shall be minimal. Check runs shall be no longer and slopes shall be no greater than that which permits uniform infiltration, evaporation and maximum practical efficiency. The frequency of by-products application to any given area within the permit location shall not exceed the agronomic rate, but may be done in two or three lifts to allow for even drying.

3. Within twenty-four hours of deposition at the site, the food processing by-product shall be spread and crushed with a tandem drag or equivalent. The by-product shall dry for a minimum of 48 hours after which it shall be disced or harrowed. The soil should be worked to an appropriate depth. Alternate discing or harrowing and drying until final drying and incorporation into the soil are complete. In the event of inclement weather, the site operator may invoke the contingency plan outlined in the plan of operation upon approval by the DER.

4. The applicant shall maintain the following minimum setbacks for all by-product areas:

By-Product Application Setback Definition	Setback (feet)
Edge of by-product area to public property (e.g., street)	300'
Edge of by-product area to other non-owned agricultural property	100'
Edge of by-product area to occupied residences (on-site)	150'
Edge of by-product area to occupied residences (off-site)	300'

5. All cans, metal, wood, plastic, paper, cardboard, and other refuse in the food processing by-product at the site shall be removed and placed in approved containers and disposed of at an approved refuse disposal site. This refuse shall be removed and properly disposed of as needed.

6. Crops shall be grown on the land application areas. Crops shall be selected based on nutrient uptake capacity, tolerance of anticipated soil moisture and salinity conditions, water needs and evapotranspiration rates. All crops shall be grazed or they shall be harvested and removed from the by-product areas at least once per year.

7. By-product shall be tested for the following parameters and constituents: moisture, total nitrogen, organic carbon, sodium, potassium, calcium, magnesium, and phosphorus.

8. Application rates would be based on agronomic rates. An agronomic rate is that amount of by-products which meets a crop requirement without application of any by-product constituent in excess of crop requirements or as defined by the University of California Cooperative Extension. "Crop requirement," s used herein, refers to the amount of nutrients or constituents necessary for the selected crop and agronomic rate

must consider the amount already available in the soil profile from ground surface to rooting depth prior to by-product application. Mass loading rates for nutrients and degradable organic compounds shall be based on the character of the by-product, crop, soil, climate and other nutrient sources.

9. Soil samples from fields to which by-products are applied shall be analyzed for cation exchange capacity, plant nutrients, total organic carbon, salinity, and sodicity. Plant nutrients must include total nitrogen, nitrate and ammonium nitrogen, available phosphorous (Olsen), potassium, magnesium, calcium and sodium. Saturation paste samples shall be analyzed for soluble salts (electrical conductivity), pH, and buffer pH (lime requirement).

   Samples shall be drawn from 1-foot intervals to the rooting depth. Alternative sampling intervals may be employed with technical justification, Each field scheduled to receive by-products in any given year should be sampled in late spring or early summer prior to the by-products application. Obtaining representative samples is critical to getting valid and interpretable analytical results. One method to ensure representative samples are collected is to conduct the soil sampling as follows. Collect soil samples from the depth intervals of 0-12", 12-24", and 24-36" at 10 to 20 sites per field based on geostatistical-based standards of practice. Mix samples taken from the same depth intervals to form a single composite sample for that depth interval. This composite sample should have a minimum weight of 1 lb. Submit each composite sample to a certified laboratory for analysis, for a total of three composite samples per field representing the three depths.

10. Land application of by-product to any sub-area or irrigation check not having a fully functional tail water/runoff control system is prohibited.

11. Applicant shall avoid excessive use of food processing by-product or practices which may create objectionable odors, soil conditions that are harmful to crops and degradation of underlying groundwater by overloading the shallow soil profile and causing by-product constituents (organic carbon, nitrate, other salts and metals) to percolate below the evaporative root zone.

12. Within sixty (60) days of the cessation of deliveries of food processing by-product to the site or at the end of the site season, the operator shall report to the DER the total amount of by-product delivered to the site (tons); the amount of by-product delivered daily (tons); a record of fields where by-products are applied, rate of application and total application/year/field; and by-product and soil sampling and testing data.

DIRECT FEED OPERATIONS SHALL ALSO COMPLY WITH THE FOLLOWING TERMS AND CONDITIONS

Direct Feed operations shall also contain the following information:

Indicate what type of livestock or poultry will be fed. List the percentage (by dry weight) of the feed ration at which this by-product will be used. List the number of lactating and non-lactating animals. List the number of livestock or poultry that will consume the by-product, or a list of purchasers and their intended use.

Direct Feed operations shall also comply with the following terms and conditions:

1. The by-product receiving pad shall be constructed of cement or asphalt; it must have adequate drainage facilities and prevent leaching. The pad shall be kept clean of accumulated by-product and maintained to prevent fly and mosquito production and objectionable odors.

2. By-product shall be fed on cement, asphalt or other approved manger and not applied to open ground.

3. Food processing by-product must be processed or fed within twenty-four (24) hours of delivery to the site. If the by-product is not processed or consumed within twenty-four (24) hours after delivery, no additional by-product shall be delivered to the site until such time as all by-products at the site has been consumed or properly processed per the procedures in the current site plan of operation.

4. No liquid or runoff from food processing by-product use areas shall be discharged from or allowed to drain off-site or onto adjacent property. The site shall be operated in conformance with the "Minimum Guidelines for Protection of Water from Animal Wastes," issued by the Regional Water Quality Control Board.

5. Food processing by-product used as an animal feed shall conform to the applicable sections of the "Commercial Feed Law and Regulations", as issued by the California Department of Food and Agriculture. The permit holder shall provide confirmation satisfactory to the Department that the feed meets the applicable requirements of the California Food & Agriculture Code, including but not limited to compliance with labeling, testing, and receiving sections of the Code.

6. By-product shall be tested for the following attributes: moisture, total nitrogen, organic carbon, sodium, potassium, calcium, magnesium, and phosphorus.

7. Within sixty (60) days of the cessation of deliveries of food processing by-product to the site or at the end of the site season, the operator shall report to the DER the amount of by-product delivered daily (tons); the total amount of by-product delivered to the site (tons); and by-product and soil sampling and testing data.

DEHYDRATION OPERATIONS SHALL ALSO COMPLY WITH THE FOLLOWING TERMS AND CONDITIONS

1. The by-product receiving pad shall be constructed of cement, asphalt or compacted surface area, it must have adequate drainage facilities, and prevents leaching. The pad shall be kept clean of accumulated by-products and maintained to prevent fly and mosquito production and objectionable odors.

2. By-product shall remain on the receiving pad no longer than 24 hours before processing commences.

3. By-product shall be tested for the following attributes: moisture, total nitrogen, organic carbon, sodium, potassium, calcium, magnesium and phosphorus.

4. Within sixty (60) days of the cessation of deliveries of food processing by-product to the site or at the end of the site season, the operator shall report to the DER the amount of by-product delivered daily (tons); the total amount of by-product delivered to the site (tons); and by-product and soil sampling and testing data.

5. Site shall comply with appropriate Regional Water Quality Control Board requirements which may include individual or general WDRs

COMPOSTING OPERATIONS SHALL ALSO COMPLY WITH THE FOLLOWING TERMS AND CONDITIONS

1. The by-product receiving pad shall be constructed of cement, asphalt or compacted surface area, it must have adequate drainage facilities, and prevent leaching. The pad shall be kept clean of accumulated by-products and maintained to prevent fly and mosquito production and objectionable odors.

2. By-product shall remain on the receiving pad no longer than 24 hours before processing commences.

3. By-product shall be tested for the following attributes: moisture, total nitrogen, density, organic carbon, sodium, potassium, calcium, magnesium. Where composting is over packed soil samples shall be taken from the surface three feet in one-foot increments. Analytes shall include at a minimum pH, nitrate nitrogen, Olsen phosphorus, ammonium acetate extractable potassium, electrical conductivity of the saturation extract and sodium absorption ratio. The top foot of access holes hall be backfilled with bentonite clay to minimize leaching and to prevent re-sampling back fill material.

4. Within sixty (60) days of the cessation of deliveries of food processing by-product to the site or at the end of the site season, the operator shall report to the DER the amount of by-product delivered daily (tons); the total amount of by-product delivered to the site (tons); and by-product and soil sampling and testing data.

5. Site shall comply with appropriate Regional Water Quality Control Board requirements which may include individual or general WDRs

F:/Data/Solid Waste/Regional Water Board/FoodProcByProdUseGuidelinesMay2006.doc

SITE ACTIVITY LOG
TONNAGE REPORT

Site Name:

Address:

Site Operator:

DATE	TYPE OF RESIDUE	HOW MUCH RESIDUE (BY TON)	HAULER	SOURCE OF RESIDUE	SOURCE IN STANISLAUS COUNTY (Yes or No)

F:/DATA/Swaste/FoodResiduePermits/TonnageReportBySite---Template

FOOD PROCESSING RESIDUE USE SURVEY
YEAR ________

Business Name : ______________________________
Business Address : ____________________________
City __________ State _____ Zip Code ______________
Mailing Address : ______________________________

City_____________State _____ Zip Code ________________
Person Completing Form : ______________________________
Phone No. : ____

TYPE OF RESIDUE[1]	HAULER(S)	USE SITE & LOCATION	WEIGHT OF RESIDUE[2] (in tons)

[1]PLEASE itemize each type of residue.
[2]PLEASE express the weight of the residue in tons.

Return the completed survey form to:
DEPARTMENT OF ENVIRONMENTAL RESOURCES
3800 Cornucopia Way, Suite C
Modesto, California 95358-9494

F:/Data/Swaste/FoodResiduePermits/FoodProcessingResidueUseSurveyForm

Appendix B

Stanislaus County
Striving to be the Best

DEPARTMENT OF ENVIRONMENTAL RESOURCES

3800 Cornucopia Way, Suite C Modesto, CA 95358-9492
Phone: 209.525.6700 Fax: 209.525.6774

FOOD PROCESSING BY-PRODUCTS PROGRAM SAMPLING AND TESTING GUIDELINES

LAND APPLICATION SITES

Sample and analyze for the following constituents in:

Soil (units)	By-product (units)	Plant Tissue (units) *
Total nitrogen (%)	Moisture (%)	Moisture (%)
Total organic carbon (%)	Total nitrogen (%)	Total Kjeldahl nitrogen (%)
Sodium[a] (mg/L)	Total organic carbon (%)	Sodium (%)
Chloride[a] (mg/L)	Sodium (mg/kg)	Chloride (%)
Potassium[a] (mg/L)	Chloride (mg/kg)	Potassium (%)
Calcium[a] (mg/L)	Potassium (mg/kg)	Calcium (%)
Magnesium[a] (mg/L)	Calcium (mg/kg)	Magnesium (%)
Available phosphorus – Olsen (mg/kg)	Magnesium (mg/kg)	Phosphorus (%)
Saturation paste extracts shall be analyzed for pH	Phosphorus (mg/kg)	*Further tests for B, Cu and Zn needed when plant toxicity symptoms observed on the site
Saturation paste extracts shall be analyzed for soluble salts - Electrical conductivity @ 25°C (μmhos/cm)	pH	
Nitrate-nitrogen (mg/kg)	Electrical conductivity @ 25°C (μmhos/cm) *EC*	
Ammonium-nitrogen (mg/kg)	Total solids[b] (mg/kg)	
Buffer pH	Fixed solids[b] (mg/kg)	
Exchangeable Sodium Percentage *ESP*	Volatile solids[b] (mg/kg)	
Cation exchange capacity *CEC*		
Sodium Adsorption Ratio *SAR*		

[a]Analysis performed in saturation paste extracts

[b]Total Solids = Fixed Solids + Volatile Solids. Using Standard Methods or EPA procedures for TDS and FDS, a measured amount of the sample is placed on a vacuum filter. Residue upon drying the filtrate is total dissolved solids (TDS). When this residue is ignited the remaining ash is fixed dissolved solids (FDS). Volatile dissolved solids (VDS), an estimate of Dissolved Organic Matter, is the loss on ignition. For total solids, volatile solids and fixed solids, a measured amount of sample would be dried to determine total solids and the dried residue would be ignited to determine volatile and fixed solids. Impact is related to totals, which can become dissolved upon dissolution or decomposition. If TDS were determined for table salt, there would be no filtrate and therefore no TDS. However there would be 100% total solids.

Submit laboratory results to the Department within 30 days of receipt.

Sampling quantity and frequency is site-specific and determined at the time of permit issuance or re-issuance. If unspecified as a permit condition, initiate the following protocol:

Soil	By-product	Plant Tissue **
Pre-application and post-cropping sampling is required. Sample in late spring or early summer prior to by-product application. Post-cropping sampling for one application period may serve as pre-application sampling for another period, if appropriate. Follow sampling protocol as provided in the *Regulations for the Use of Food Processing By-products in Stanislaus County by Permitted Use Sites*	The site operator shall record the types and sources of food processing by-product from each truckload. Sampling shall occur prior to land spreading. For each load, collect one composite sample from a minimum of four separate, random locations within the load.	Record harvest portion biomass (lbs/acre). At least three composite crop samples shall be collected from each harvest in each field that has received food processing by-products during the preceding twelve months. Collect whole plant tissue samples at 10 to 20 locations per each composite sample. Each composite sample shall have a minimum weight of one pound. Plant tissue samples may be collected from hay bales using a hay sampler. Refer to the sampling protocol as provided in the *Manual of Best Practices for Application of Food Processing By-products on Farmlands*

These guidelines were developed to facilitate understanding of the sampling protocol as described in the current Stanislaus County Code, Title 9 and its adopted documents as referenced. Adherence to the site-specific Plan of Operation, Stanislaus County Code, *Regulations for the Use of Food Processing By-products in Stanislaus County by Permitted Use Sites*, and the *Manual of Best Practices for Application of Food Processing By-products on Farmlands* is required.

*To determine an *annual nutrient budget*, it is essential to obtain the plant tissue samples from all cuttings or harvests that occur during the first 12-month period following food processing by-products applications.

DIRECT FEED SITES

Sample and analyze for the following constituents in:

By-product (units)
Moisture (%)
Total nitrogen (%)
Total organic carbon (%)
Sodium (mg/kg) or (% w/w)
Chloride (mg/kg) or (% w/w)
Potassium (mg/kg) or (% w/w)
Calcium (mg/kg) or (% w/w)
Magnesium (mg/kg) or (% w/w)
Phosphorus (mg/kg) or (% w/w)
pH

Submit laboratory results to the Department within 30 days of receipt.

Sampling quantity and frequency is site-specific and determined at the time of permit issuance or re-issuance. If unspecified as a permit condition, initiate the following protocol:

By-product
The site operator shall record the types and sources of food processing by-product from each truckload. Sample one time annually for each by-product type

DEHYDRATION SITES

Sample and analyze for the following constituents in:

By-product (units)
Moisture (%)
Total nitrogen (%)
Total organic carbon (%)
Sodium (mg/kg) or (% w/w)
Chloride (mg/kg) or (% w/w)
Potassium (mg/kg) or (% w/w)
Calcium (mg/kg) or (% w/w)
Magnesium (mg/kg) or (% w/w)
Phosphorus (mg/kg) or (% w/w)
pH
Total solids (mg/kg) or (% w/w)
Fixed solids (mg/kg) or (% w/w)
Volatile solids (mg/kg) or (% w/w)

Submit laboratory results to the Department within 30 days of receipt.

Sampling quantity and frequency is site-specific and determined at the time of permit issuance or re-issuance. If unspecified as a permit condition, initiate the following protocol:

By-product
The site operator shall record the types and sources of food processing by-product from each truckload. Sample one time annually for each by-product type

REFERENCES

Stanislaus County Code, Title 9, Chapter 9.88, which incorporates the *Regulations for the Use of Food Processing By-products in Stanislaus County by Permitted Use Sites* and the *Manual of Best Practices for Application of Food Processing By-products on Farmlands* prepared for Stanislaus County by CATI

Researcher's Executive Summary, CATI

Progress report 3/9/09 – Horacio Ferriz

I am devotedly working on the final report for both the infiltration and soil moisture studies, and expect to have a full draft of the joint report available for peer review by March 31, 2009.

We are also working on the Phase 2 lysimeter study, and I figured I would share with you some of the first data we are receiving about the TDS, FDS, and VDS content on both the byproducts themselves, and in the infiltrating irrigation water:

Byproducts

Fresh chopped tomatoes (Tomato 1), the tomato paste used in the experiments (Tomato 2), and a liquefied sample of the fruit cocktail (Fruit 1), were characterized in terms of field pH, Eh, and calculated ionizable Total Dissolved Solutes (ITDS). In addition, filtrates (i.e., separated interstitial "juice") of all three slurries were analyzed in the chemical laboratory for Total Dissolved Solutes (the residual left after drying at a temperature of 80 C), and Fixed Dissolved Solutes (FDS) (the residual left after firing to a temperature of 400 C). The loss during firing (i.e., TDS-FDS) is presumed to be residual organic compounds "burnt" at high temperature, and is referred to as Volatile Dissolved Solutes (VDS; VDS = TDS-FDS). The following table summarizes the results (Appendix 1):

Slurry	pH	Eh	ITDS	TDS	FDS	VDS	VDS
		µS	ppm	mg/l	mg/l	mg/l	% of TDS
Tomato 1	4.70	5,200	2,600	19,000	5,080	13,920	73%
Tomato 2	4.22	13,685	6,842	34,900	11,900	23,000	66%
Fruit 1	4.00	1,920	3,840	71,300	1,700	69,600	98%
Tomato 1 (dup)				11,600	4,600	7,000	60%
Tomato 2 (dup)				18,600	8,000	10,600	57%
Fruit 1 (dup)				66,700	1,367	65,333	98%

The available data is admittedly scattered, but the following conclusions can be reached:

- Natural tomatoes have a low pH and relatively high TDS. Ionizable TDS increases as TDS or FDS increase, but the sample is too small to allow for a meaningful correlation. Since ionizable TDS is easy to measure with a field probe, it would be advantageous to measure a larger number of materials to try to derive a meaningful correlation between field and laboratory measurements.
- Processed tomatoes have low pH values that are comparable to those of the natural tomatoes, but their TDS and FDS loads are nearly twice as large.
- For both natural and processed tomatoes the VDS load is between 60 and 70% of the TDS.
- Fruit cocktail has low pH values and very high TDS loads. However, most of the load is in the form of VDS, which is 98% of the TDS. The high values are not surprising, in that fruit has a naturally high content of sugar, and this content is considerably increased by the addition of syrup.

ATTACHMENT E

It seems reasonably to assume that microorganisms in the soil would consume the VDS load, so from the standpoint of potential load to groundwater the relevant parameter would be FDS, which from the table above could be expected to range between 1,000 and 12,000 mg/l in interstitial "juice".

Infiltrating irrigation water

We have analyzed TDS and FDS in 20 samples of infiltration water, and then have calculated VDS by difference as explained in the previous section. The results are:

TDS mg/l	FDS mg/l	VDS mg/l	VDS in %
955	705	250	26%
700	505	195	28%
1370	950	420	31%
640	440	200	31%
1370	940	430	31%
555	380	175	32%
500	340	160	32%
1330	850	480	36%
1570	1000	570	36%
1110	690	420	38%
890	545	345	39%
2790	1700	1090	39%
1420	860	560	39%
3180	1850	1330	42%
3810	2090	1720	45%
4090	2145	1945	48%
4260	2160	2100	49%
3600	1815	1785	50%
3860	1240	2620	68%

The data above shows that VDS content is generally between 30 to 50% of the TDS load in infiltrating waters.

Progress report 5/11/09 – Horacio Ferriz

1. Lysimeter study

The CSUS group has maintained and sampled the 10 lysimeters for about 6 months now.

L1 through L5 are lysimeters filled with Turlock silty sand (SW/SM). All five lysimeters, L1 through L5, were dosed with 250 grams of chicken manure on 10/1/08, as a fertilizer. L1 and L2 are the control lysimeters, to which no byproducts were added. L3 through L5 were dosed on 10/22/08 with 3 kg of fruit cocktail, 3 kg of chopped tomatoes, 1 gram of copper sulfate, and 1 gram of potassium iodide.

L1 through L5 are lysimeters filled with Oakdale silty clay (CH); no fertilizer was applied. L6 and L7 are the control lysimeters, to which no byproducts were added. L8 through L10 were dosed on 10/22/08 with 3 kg of fruit cocktail, 3 kg of chopped tomatoes, 1 gram of copper sulfate, and 1 gram of potassium iodide.

A liquefied sample of the chopped canned tomatoes (Tomato 2), and a liquefied sample of the fruit cocktail (Fruit 1), were characterized in terms of field pH, Eh, and calculated ionizable Total Dissolved Solutes (ITDS). In addition, filtrates (i.e., separated interstitial "juice") of the three slurries were analyzed in the chemical laboratory for Total Dissolved Solutes (the residual left after drying at a temperature of 80 C), and Fixed Dissolved Solutes (FDS) (the residual left after firing to a temperature of 400 C). The loss during firing (i.e., TDS-FDS) is presumed to be residual organic compounds "burnt" at high temperature, and is referred to as Volatile Dissolved Solutes (VDS; VDS = TDS-FDS). The following table summarizes the results (Appendix 1):

Slurry	pH	Eh	ITDS	TDS	FDS	VDS	VDS
		µS	ppm	mg/l	mg/l	mg/l	% of TDS
Tomato 2	4.22	13,685	6,842	34,900	11,900	23,000	66%
Tomato 2 (dup)				18,600	8,000	10,600	57%
Fruit 1	4.00	1,920	3,840	71,300	1,700	69,600	98%
Fruit 1 (dup)				66,700	1,367	65,333	98%

The available data is admittedly scattered, but the following conclusions can be reached:

- Processed tomatoes have a low pH and relatively high TDS. The VDS load is between 60 and 70% of the TDS.
- Fruit cocktail has low pH values and very high TDS loads. However, most of the load is in the form of VDS, which is 98% of the TDS. The high values are not surprising, in that fruit has a naturally high content of sugar, and this content is considerably increased by the addition of syrup.

It seems reasonably to assume that microorganisms in the soil would consume the VDS load, so from the standpoint of potential load to groundwater the relevant parameter would be FDS, which from the table above could be expected to range between 1,000 and 12,000 mg/l in interstitial "juice".

ATTACHMENT F

The lysimeters were sampled on 10/21/08 (only L3, L6, and L9), 12/15/08, 1/29/09, and 2/25/09. The original plan was to excavate the lysimeters in March 2009, but since this was not done, I would like to acquire one more round of samples later in May. The problem is that following a long period of little irrigation, the L1 to L5 lysimeters have stopped draining (probably due to capillary forces). Surprisingly, a little drainage has been taking place in the L6 to L10 lysimeters. To solve the drainage problems I plan to apply a gentle vacuum on the drain tube, so we are now in the process of putting together a suitable apparatus.

2. Preliminary chemistry data

The table in the following page is an excerpt of the chemical data accumulated so far, with some preliminary interpretations. It is probably premature, but I think there are a couple of worthwhile points to observe. For convenience I have selected a monovalent anion (Cl^-), a divalent anionic complex (SO_4^{2-}), a common monovalent cation (K^+), a common divalent cation (Ca^{2+}), a "doped" heavy metal (Cu^{2+}), TDS, and FDS. I see the following patterns emerging:

- Local rain water is very low in all dissolved solutes, which is as expected.

- Irrigation water, in all cases drawn from the same well, is of good quality, and fairly consistent in amount of dissolved solutes, with Cl at about 20 mg/l, SO_4 at about 13 mg/l, FDS at about 335 mg/l, K at about 3.3 mg/l, Ca at about 54 mg/l, and no Cu.

- For the L1 through L5 lysimeters, there was little difference between the control and doped lysimeters for SO_4 and K between the 12/15/08, 1/29/09, and 2/25/09 samplings (the data are admittedly scattered, but the differences are either small or inconsistent). There are clear differences in the values of Cl, TDS, FDS, Ca, and Cu.

- For the L1 through L5 lysimeters, on 12/15/08 Cl, TDS, FDS, and Ca in the doped lysimeters was slightly but consistently higher than in the control lysimeters. For both the 1/29/09 and 2/25/09 samplings the difference was considerable. Since the doping took place in late October, and the effects of chemical transport were not prominent until late January, one can assume a rate of mass transport of 20 inches per 3 months, or about 0.2 inches per day.

- For the L1 through L5 lysimeters, Cu started to be detected on 12/15/08. Since the doping took place in late October, one can assume a rate of mass transport for this particular heavy metal of 20 inches per two months, or about 0.3 inches per day.

- For the L6 through L10 lysimeters, there was little difference between the control and doped lysimeters for SO_4, FDS, K, and Ca between the 12/15/08, 1/29/09, and 2/25/09 samplings (the data are admittedly scattered, but the differences are either small or inconsistent). There are clear differences in the values of Cl, TDS, FDS, Ca, and Cu.

		Cl	SO_4	TDS	FDS	K	Ca	Cu
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1/29/2009	Rain	<0.1	<0.2	20	15	<0.5	0.3	0.01
1/29/2009	Irrigation water	19.8	11.0	395	330	3.1	54.1	<0.01
12/15/2008	Irrigation water	22.2	14.4	415	335	3.5	55.7	<0.01
12/15/2008	Irrigation water	21.4	12.2	410	340	3.1	53.4	<0.01
10/21/2008	L3	119	53.3	505	405	3.3	96.8	<0.01
10/21/2008	L6	30.7	9.5	890	670	28.3	136	<0.01
10/21/2008	L9	33.9	6.9	870	650	30.6	127	<0.01
12/15/2008	L1	141	94.9	585	380	3.1	88.8	<0.01
12/15/2008	L2	136	105	610	500	2.7	110	0.03
12/15/2008	L3	192	80.0	1680	1150	2.8	282	0.01
12/15/2008	L4	146	71.3	755	625	2.1	130	0.01
12/15/2008	L5	170	46.8	3160	1750	3.6	434	0.02
12/15/2008	L6	31.6	39.8	960	760	23.1	158	<0.01
12/15/2008	L7	35.9	5.6	1850	1450	23.0	317	<0.01
12/15/2008	L8	37.8	<0.2	2510	1870	24.0	404	<0.01
12/15/2008	L9	59.1	6.8	1540	1180	21.6	263	<0.01
1/29/2009	L1	108	113	640	440	1.0	94.0	0.02
1/29/2009	L2	52.3	46.1	700	505	1.5	111	0.03
1/29/2009	L3	855	62.0	4260	2160	2.1	568	<0.01
1/29/2009	L4	829	68.2	3180	1850	2.6	560	0.01
1/29/2009	L5	453	11.3	4090	2145	3.4	642	0.01
1/29/2009	L6	27.8	49.0	955	705	22.2	142	<0.01
1/29/2009	L7	32.2	23.9	1370	940	19.2	252	<0.01
1/29/2009	L8	208	7.0	3860	1240	17.6	292	<0.01
1/29/2009	L9	178	21.3	1370	950	22.6	217	<0.01
1/29/2009	L10	276	13.9	1310	890	20.2	220	<0.01
2/25/2009	L1	70.5	101	500	340	1.1	76.3	0.03
2/25/2009	L2	78.7	121	555	380	1.6	93.2	0.03
2/25/2009	L3	888	19.2	3810	2090	2.5	624	<0.01
2/25/2009	L4	796	38.2	2790	1700	2.4	503	0.01
2/25/2009	L5	548	5.8	3600	1815	3.3	562	0.02
2/25/2009	L6	24.1	29.6	890	545	23.0	142	<0.01
2/25/2009	L7	25.1	0.6	1110	690	16.3	199	<0.01
2/25/2009	L8	354	0.3	1420	860	21.6	261	<0.01
2/25/2009	L9	384	9.6	1570	1000	25.4	256	<0.01
2/25/2009	L10	287	3.8	1330	850	20.8	219	<0.01

- For the L1 through L5 lysimeters, on 12/15/08 Cl in the doped lysimeters was slightly but consistently higher than in the control lysimeters. For both the 1/29/09 and 2/25/09 samplings the difference was considerable. Since the doping took place in late October, and the effects of chemical transport were not prominent until late January, one can assume a rate of mass transport of 20 inches per 3 months, or about 0.2 inches per day. It would seem that anions are not being retained by adsorption unto the soil.

- For the L1 through L5 lysimeters, Cu never "broke through", probably because it got adsorbed unto the clay matrix. Na, which is not included in the table, is detected in both control and doped samples, but it shows very little difference between both sets throughout the duration of the experiment. This suggests to me that cations are being effectively retained by adsorption.

The infiltration study indicated a better hydraulic performance from silty sands than from ripped or cracked clay soils, but the chemical transport observations made above suggest good adsorption of cations unto clay soils. We are going to have to explore this issue further, by running again the experiments with a common loam soil (basically a silty sand with clay), an alakline silty sand soil, and an alkaline clayey soil.

PowerPoint Presentation

Food Processing By-product Use Program Update

Sonya K. Harrigfeld, Director

Jami Aggers, Assistant Director

Dr. Sajeemas (Mint) Pasakdee, Soil Scientist/Agronomist

Department of Environmental Resources

September 29, 2009

Background Information

- The Food Processing By-product Use Program (Program) has controlled nuisance conditions for over 30 years.
- Allows reuse of by-products as a viable agricultural commodity
- By-products are largely used as soil amendments or animal feed.

Background Information (cont'd.)

- The Regional Water Quality Control Board (RWQCB) issued a *Resolution Regarding Reuse of Food Processing Byproducts* (Resolution) in 2006, requiring specific data in order to validate the Program's ability to protect water quality.
- The Program was allowed to continue while performing a literature review and additional scientific research (Research Project).
- Required submittals were completed by assigned due dates.

Program Approval

- Stanislaus County Ordinance, Chapter 9.88 (Ordinance) was adopted on February 26, 2008, the final requirement of the Resolution
- Written approval of the Program was provided in a letter from the RWQCB (Approval letter) on June 8, 2009.
- The RWQCB affirmed that Stanislaus County manages food processing by-products so that they can be “beneficially used in an environmentally sound manner.”

Program Approval (cont'd.)

- The Approval letter qualifies all permitted Program sites to be included under a Waiver of Reports of Waste Discharge and Waste Discharge Requirements for Specific Types of Discharge within the Central Valley Region.
- This accomplishment was made possible due to collaborative efforts of Department staff, by-product site operators, local food processors, and the CSU, Fresno Foundation (Foundation) research team.

Program Update

- The Research Project consists of two phases, an initial phase (Phase 1) and a second scope of work (Phase 2).
- It was noted at the most recent Program update provided to the Board on February 12, 2008, that Phase 1 data collection was complete.
- Phase 2 research is currently being performed to address data gaps identified during Phase 1.

Program Update - Phase 1

- The Research Project is being conducted by the Foundation research team.
- Phase 1 work began with a literature review of existing data.
- Phase 1 studies focused on analyzing by-product constituents, movement or lack of movement of those constituents through the soil profile, and potential impacts to groundwater and surface water those constituents may pose, if identified.

Phase 1 Completed Work

- A soil moisture probe field study
- An infiltration study
- A bench-scale loading rate study
- A nutrient management plan

Phase 1 Study Results

Results of the soil moisture probe field study and the infiltration study were provided by Horacio Ferriz, Ph.D., P.G. in a report entitled, *Fluid Infiltration in Soils Used for Land Application of Food Processing Vegetable Byproducts*.

1. Water and solutes propagate through some soil profiles.

Phase 1 Study Results (cont'd.)

2. Silty sands and sandy loam soils seem to have the lowest infiltration rates, and are recommended for land application.
3. Measurements of infiltration rates are useful to determine suitability of soil for land application.
4. Managed irrigation could limit water propagation through the soil profile.

Phase 1 Study Results (cont'd.)

Results of the bench-scale loading rate study were provided by Dr. Sajeemas (Mint) Pasakdee, Soil Scientist/Agronomist in a memo with the subject heading: "Bench scale studies of peach by-products applied at various loading rates."

1. Application of peach by-products significantly increased macro- and micronutrients, and trace elements, to sandy loam and silt loam soils.

Phase 1 Study Results (cont'd.)

2. Contribution of salt from the by-products is minimal.
3. Growers are expected to benefit economically from a reduction in the use of chemical fertilizer inputs with replacement of less expensive by-products.

Phase 1 Study Results (cont'd.)

4. Considering annual elemental inputs from by-products, crop removal rates, crop selection, irrigation management, and proper site management, application of by-products on farmlands will pose minimal impacts to groundwater quality.

Program Update - Phase 2

- Phase 2 work began on September 1, 2008, and will continue through August 31, 2010.
- Phase 2 studies focus on soil moisture content, percolation of irrigation water through soils, movement or lack of movement of salts through the soil profile, and the identification of potential impacts to groundwater and surface water with the introduction of these nutritive salts (e.g. potassium, calcium and magnesium).

Phase 2 Studies – In Progress

- Crop nutrient balance field studies to advance knowledge regarding crop nutrient removal patterns
- Soil moisture content field studies, after by-product application
- Field trial experiments to study loading rates and to further develop good farming practices for use of by-products as a supplemental fertilizer

Phase 2 Studies – In Progress (cont'd.)

- Modeling studies for irrigation water movement through lysimeters
- Modeling studies for salt/solute movement
- Review of existing relevant studies
- After all data has been collected, revise the *Manual of Best Practices for Application of Food Processing By-products on Farmlands*

Phase 2 Progress Reports

- Two reports completed regarding the irrigation water movement and salt/solute movement studies. Most recent findings are as follows:
  1. Volatile Dissolved Solids (VDS) may be as high as 98% in processed fruits. It is reasonable to assume that microorganisms in the soil would consume the VDS load, leaving Fixed Dissolved Solids as a more relevant parameter of focus.

Phase 2 Progress Reports (cont'd.)

2. Attenuation of cations in clayey soils is stronger than in sandy soils. This allows adsorption of some nutritive salts to clayey soils, preventing transport through the soil.
3. A 6-month experiment is underway re: the chemical behavior of solutes as they percolate through various soil profile types.

Phase 2 Progress Reports (cont'd.)

4. It is important to maintain the balance and compromise between good hydraulic performance and good geochemical performance.

Foundation sources of funding support: CDFA Specialty Crop Grant and Stanislaus County for Phase 1 research, and CSU-Agricultural Research Initiative (ARI) and Stanislaus County for Phase 2 research

Staff Recommendation

- Accept the Food Processing By-product Use Program update

Questions?