Appendix A
Best Management Practices

INTRODUCTION

The Huntington Power Plant has implemented Best Management Practices (BMPs) to prevent or minimize the potential for degradation of the surface and ground water sources. These practices are utilized in conjunction with Huntington's Storm Water Pollution Prevention Plan, Spill Prevention Control and Countermeasures Plan, Solid and Hazardous Waste Management Plan, Waste Water Land Application Plan, and Site Wide Monitoring and Sampling Plan.

Ground Water Discharge Permit (GWDP) Facilities

The facilities included in the Ground Water Discharge Permit No. UGW150002 (Table 1) are inspected on a monthly basis. In addition to the routine visual inspection of the permitted facilities, a network of surface and ground water monitoring locations have been established to monitor for any degradation of the water leaving the site. These facilities are listed in Table 1, along with the surface and ground water monitoring points established for each facility.

Table 1.
Monitoring Points for Ground Water Discharge Facilities
Huntington Power Plant

Pond/PSA	**Year of Construction**	**Volume (acre-ft)**	**Liner Type**	**Monitoring Point(s)**	
				Ground Water	Surface Water
Raw Water Pond	1977	336	None		H-1
Irrigation Pond	1977	329	Clay	HWW-7	UPL-13
Duck Pond	1979	6	None	HDP-3 NH-4W	Ck @ HDP-3 H-11 H-12
Waste Water Decanting Basins	2015	1	Concrete	HWW-4	H-2

Potential Source Areas (PSAs)

Scrap Yards

Best management practices include:

- Consolidate scrap yards where possible and minimize their size.
- Control the storage of scrap and materials that may contain residual fluids.

- Provide level grades and gravel surfaces to retard flows and limit the spread of spills.
- Minimize storm water run-on/runoff through the construction, maintenance, and use of berms, ditches, storage facilities, and/or collection/treatment systems.
- Inspect scrap areas at least annually. Inspections will monitor compliance with operating plans.
- Take fugitive dust control measures to minimize emissions.
- Monitor upstream and downstream surface and ground water locations in accordance with Ground Water Permit. Specific monitoring points for the scrap areas are listed in Table 2.

Table 2.
Scrap Area Monitoring Point
Huntington Power Plant

Monitoring Point	Location in Flow Field
HPS-1	Downgradient of Plant Activities
HSW-1	Downgradient of Plant Activities

Old Combustion Waste (Ash) Landfill
Best management practices include:

- Minimize storm water run-on/runoff through the construction, maintenance, and use of berms, ditches, storage facilities, and/or collection/treatment systems.
- Inspect class IIIb industrial waste landfill at least once per quarter. Inspections will monitor compliance with operating plans.
- Monitor the construction and contemporaneous reclamation of the ash pile.
- Take fugitive dust control measures to minimize emissions.
- Monitor upstream and downstream surface and ground water locations in accordance with Ground Water Permit. Specific monitoring points for the old combustion waste landfill are listed in Table 3.

Table 3.
Old FGD Waste Landfill Monitoring Points
Huntington Power Plant

Monitoring Point	Location in Flow Field
LF-1O	Upgradient of old Combustion Waste Landfill
LF-2O	Upgradient of old Combustion Waste Landfill
LF-3O	Downgradient of old Combustion Waste Landfill
LF-4O	Downgradient of old Combustion Waste Landfill
LF-6O	Downgradient of old Combustion Waste Landfill
LF-7O (Nested)	Downgradient of old Combustion Waste Landfill
NF-OLF	Surface Downgradient of old Combustion Waste Landfill
Ck@DP3	Surface Downgradient of old/new Combustion

	Waste Landfill

Discharge Minimization for the Old Combustion Waste Landfill
The closure of the Old Landfill area consists of leaving all combustion wastes in place and constructing an Evapotranspiration (ET) cover over all the material except the footprint of the industrial waste landfill, and Monitored Natural Attenuation (MNA). The cover is constructed to prevent water deposited on the surface of the cap from infiltrating into the combustion waste. The Sampling and Analysis Plan focuses on the ground water and surface water downgradient of the landfill area.

Reducing infiltration combined with monitored natural attenuation (MNA) is the preferred way to restore water quality.

- Within the capped area, the expanded ET cap will eliminate the infiltration of precipitation into the landfill and eliminate run on from the surrounding terrain, thereby, allowing the existing liquid in the landfill to drain.
- MNA is allowing PacifiCorp to track the ground water elevations and contaminant concentrations over time. If decreases in contaminant concentrations are not observed, then the industrial waste landfill will also be capped and the industrial waste landfill would be relocated. This monitoring allows PacifiCorp to document the effectiveness of the corrective action and to ensure protection of public health and the environment.

Research Farm
Best management practices include:

- Minimize storm water run-on/runoff through the construction, maintenance, and use of berms, ditches, and/or storage facilities. The control devices will be inspected regularly to confirm the integrity of the facilities.
- Control irrigation application rate to prevent surface runoff and deep percolation.
- Monitor upstream and downstream surface and ground water locations in accordance with Ground Water Permit. Monitoring Points specific to the Research Farm are listed in Table 4.

Table 4.
Research Farm Monitoring Points
Huntington Power Plant

Monitoring Point	Location in Flow Field
NH-1W	Downgradient Research Farm
NH-2W	Lower Research Farm
NH-3W	Lower Research Farm

NH-4W	Mid- Research Farm/Downgradient of Duck Pond Drainage
NH-5W	Mid- Research Farm
NH-6W	Mid- Research Farm
NH-7W	Upgradient of Research Farm
NH-8W	Upgradient of Research Farm
NH-9W	Mid- Research Farm
RG-1	Downgradient Research Farm
UPL-13	Surface Irrigation Pond
H-1	Surface Upgradient of Facility
H-2	Surface Upgradient of Research Farm
UPL-9	Surface Downgradient of Facility & Research Farm

Process Water Ponds

Best management practices include:

- Clay, synthetic membrane, or concrete liners will be utilized in future construction where appropriate.
- Liner integrity will be maintained on ponds constructed with liners. Inspect ponds at a minimum semi-annual for seeps or other signs of leakage.
- Avoid overfilling ponds.
- Minimize waste water flows.
- Monitor upstream and downstream surface and ground water locations in accordance with Ground Water Permit. Monitoring points for process water ponds are shown in Table 1.

Flue Gas Desulfurization (FGD) Waste

Best management practices include:

- Eliminate free liquid content of FGD slurry. Use drum vacuum filters to remove free liquid from slurry prior to placement on the ash landfill.
- Clean-up spills and take fugitive dust control measures to minimize emissions.
- Monitor upstream and downstream surface and ground water locations in accordance with the Ground Water Permit. Monitoring points for FGD wastes at the old combustion waste landfill are shown in Table 3.

Coal Pile

Best management practices include:

- Storm water run-on/runoff should be minimized through the construction, maintenance, and use of berms, ditches, storage facilities, and/or collection/treatment systems.
- Minimize fugitive dust by taking measures to control emissions.
- Monitor upstream and downstream surface and ground water locations in accordance with Ground Water Permit. Monitoring well **HCP-6** will be included in the semi-annual monitoring network of wells to give early warning of potential discharge of contaminants to ground water.

Plant Facilities
Specific best management practices have been developed for the following plant site categories. Each category is listed below and BMPs are described in detail in the following paragraphs.

- Good Housekeeping
- Vehicle and Equipment Cleaning, Storage, Fueling, and Maintenance Areas
- Material Storage Areas
- Loading/Unloading Areas
- Delivery Vehicles
- Ash Loading and Haul Road Areas
- Above Ground Storage Tanks, Substations, and Storage Areas
- Preventative Maintenance
- Facility Security
- Employee Training
- Continuous Improvement
- Monitor upstream and downstream surface and ground water locations in accordance with Ground Water Permit. Monitoring well **HPS-1** will be included in the semi-annual monitoring network of wells to give early warning of potential discharge of contaminants to ground water.

Good Housekeeping
Good housekeeping requires the operation and maintenance of a clean and orderly facility. All plant operations crews have specific clean-up areas assigned. In addition, site-wide clean-up days are scheduled as needed.

Vehicle and Equipment Cleaning, Storage, Fueling, and Maintenance Areas
Cleaning, storage, and maintenance of vehicles and equipment are confined to designated areas whereby the potential to degrade water sources is prevented or minimized.

The co-mingling of storm water with products used to service the vehicles and equipment is prevented or minimized through the construction, maintenance, and use of berms, ditches, storage facilities, and/or collection/treatment systems.

Appropriate devices will be utilized to collect oil, grease and vehicle and equipment fuels. Spills will be contained, absorbed and cleaned-up in a timely manner.

Material Storage Areas
Storage containers are clearly labeled and maintained in good condition. Whenever possible, enclosed facilities will be used to store materials or provide temporary covering to minimize the potential for pollutants to come in contact with storm water.
Storm water run-on/runoff will be minimized through the construction, maintenance, and use of berms, ditches, storage facilities, and/or collection/treatment systems.

Spills will be cleaned-up in a timely manner using dry clean-up methods.

Loading/Unloading Areas
Ensure that an appropriate spill control plan is in place and plant personnel are familiar with the plan. Locate shipping and receiving activities where spills or leaks can be contained.

Storm water run-on/runoff will be minimized through the construction, maintenance, and use of berms, ditches, storage facilities, and/or collection/treatment systems.

Delivery Vehicles
Vehicles that arrive to make a delivery are responsible for vehicle maintenance, and for any spills incurred while on plant site. In case of spills, the driver should call the control room for needed assistance in cleaning up any spill. Adequate spill containment and countermeasures should be in place to respond to leakage or spillage from the vehicle.

The vehicle should not be left unattended during the unloading process.

Ash Hauling Vehicles
Ash hauling vehicles will be inspected, cleaned and maintained to ensure the overall integrity of the vehicle and ash container.

Fly ash will be mixed to contain the proper amount of liquid such that fugitive dust emissions are minimized.

Ash Loading and Haul Road Areas
Good housekeeping practices will be observed to reduce and/or control the tracking of ash or residue from loading areas. The ash silo building and adjacent roadways will be cleared and cleaned of spillage and debris to minimize any contact with storm water.

Ash haul roads will be maintained in good condition to minimize bumps and uneven surfaces. The speed of the vehicles on the ash haul road will be maintained at a reasonable level for the road conditions.

Fugitive dust control measures will be taken to minimize emissions.

Storm water run-on/runoff should be minimized through the construction, maintenance, and use of berms, ditches, storage facilities, and/or collection/treatment systems.

Above Ground Storage Tanks, Substations, and Storage Areas
Above ground petroleum storage tanks and electrical transformers will be inspected in accordance with the Spill Prevention, Control and Countermeasures (SPCC) Plan and all other bulk storage tanks will be inspected on a routine basis. Appropriate secondary

containment will be provided for petroleum and bulk storage tanks to prevent spills from leaving the plant site.

Liquid level gauging devices will be provided to avoid overfilling tanks. All mobile or portable tanks will be located in a position that prevents a discharge.

All spills or releases will be cleaned-up in a timely manner.

Storm water run-on/runoff will be minimized through the construction, maintenance, and use of berms, ditches, storage facilities, and/or collection/treatment systems.

Collection Systems

Collection systems were installed to intercept leachate leaving both the New and Old Landfill areas and surface water in the Duck Pond area. A total of three collection systems were installed. The systems were installed directly below the new landfill, in the drainage below the new and old landfills, in the West End Canyon and springs near the Duck Pond inflow. The systems capture all existing surface water and a percentage of storm water generated in the area. Captured water gravity flows to the pump house sump, where it is pumped back to the facility for re-use in plant operations.

Collection System #1

Collection System #1 is located below the toe of the northwest corner of the New Landfill. System #1 intercepts and directs the surface water and shallow groundwater flows down a collection ditch. The ditch is lined with an HDPE channel lining system. A perforated 4" HDPE pipe is placed in the bottom of the ditch liner and conveys the fluid to the flanged bulkhead connection at the lowest end of the collection ditch. The ditch is covered with filter fabric and riprap and filled with medium gravel. Using a flanged connection, the perforated pipe is joined to 4-inch, solid HDPE pipe and routed from the collection system, then to the west of the existing storm water retention pond, and down an existing drainage to Collection System #2.

The pipeline is constructed with 4 inch HDPE pipe. The pipe was installed in lengths up to 40 feet and heat-welded together at the joints. The completed pipeline was placed in a ditch approximately 3 feet deep and buried with native soils to prevent freezing. The total length of the pipeline is approximately 4,000 feet.

Collection System #2

Collection System #2 is located in the natural drainage approximately 100 feet below the confluence of the drainage from the Old Landfill and the New Landfill. This system intercepts any drainage originating from the old landfill or New Landfill that is not collected by System #1.

Collection System #2 is constructed similarly to System #1. In the event of a large storm water runoff volume flowing down the natural drainage, all flows over 120 gpm will proceed down the drainage to the existing Duck Pond. The Duck Pond will be used as a storm water collection basin which will then be discharged to the Pumphouse when flows from the collection systems have returned to normal.

Collection System #3A

Collection System #3A collects surface water flowing through the West End Canyon. System #3A is constructed similarly to Systems #1 and #2.

Collection System #3A is not connected to Systems #1 and #2.

Collection System #3B

Collection System #3B collects water flowing from a seep/spring area located between the Duck Pond and the West End Canyon. System #3B is constructed similar to the previously described systems. The pipeline from System #3B is connected to the pipeline from System #3A and routed to the Pumphouse.

Pond Dredging

Periodically, dredging of site holding ponds is required. Dredging wastes will be disposed of according to the following procedure.

- Dredging materials will be removed from the pond and spread in one of two dewatering pads.
- Storm water within the dewatering pads will be contained.
- When the material passes a paint filter test, it will be transported for disposal in the appropriate waste landfill.
- Multiple ground water monitoring wells are completed both up and downgradient of the plant area and are sampled semi-annually to monitor water quality.

Preventative Maintenance

The Plant's work management system will be utilized to monitor and inspect systems and detect conditions that could cause breakdowns or failures which have the potential to pollute.

Facility Security

Plant property will be monitored using security personnel and other surveillance tools so that the ingress and egress of those entering and exiting the property is known and the likelihood of vandalism is minimized.

Employee Training

When properly trained, Plant personnel are more capable of preventing spills, responding safely and effectively to an incident when one occurs, and recognizing a situation or condition that could result in surface or ground water contamination.

Continuous Improvement

The effectiveness of BMPs will be monitored using inspection programs whereby the information garnered can be utilized to improve upon current practices.

CONCLUSION

Through the implementation of Best Management Practices the entire environmental management system will better recognize impacts, reduce pollution, improve continually, and comply environmentally.

Appendix B
Monitoring Program

Ground Water

Ground water monitoring will be conducted for the constituents shown in **Table I** in the monitoring wells shown in **Table II**.

Surface Water

The surface water monitoring locations (**Table II**) will also be sampled for the analytes shown in **Table I**.

Table I. Field & Analytical Monitoring Parameters

Field Measurements		
Water Level pH Temperature Specific Conductance		
Analytical Data		
Analyte	**Method**	**Detection Limit**
Total Dissolved Solids	E160.1/A2540C	10 mg/l
Sodium	E273.1/E200.7/E200.8	1 mg/l
Potassium	E258.1/E200.7/E200.8	1 mg/l
Magnesium	E242.1/E200.7/E200.8	1 mg/l
Calcium	E215.1/E200.7/E200.8	1 mg/l
Sulfate	E300.0	1 mg/l
Selenium	E200.8	.002 mg/l
Alkalinity	E310.1/A2320B	5 mg/l
Carbonate	A2320B	5 mg/l
Bicarbonate	A2320B	5 mg/l
Chloride	E300.0/A4500CLB	1 mg/l
Nitrate + Nitrite	E353.2	0.1 mg/l
Boron	E200.7/E200.8	0.01 mg/l

Table II. Monitoring Locations
Huntington Power Plant

Potential Source Areas w/ Well IDs	**Purpose**	**Justification**
Ash Landfill (Old)		
LF-1O	CAP/BMP	Upgradient well for Old Ash Lf
LF-2O	CAP/BMP	Downgradient well for Old Ash Lf
LF-3O	CAP/BMP	Upgradient well for Old Ash Lf and storm water pond
LF-4O	CAP/BMP	Downgradient well for Old Ash Lf and storm water pond

Potential Source Areas w/ Well IDs	Purpose	Justification
LF-6O	CAP/BMP	Downgradient well for Old Ash Lf and storm water pond
LF-7Od	CAP/BMP	Downgradient well for Old Ash Landfill
Ash Landfill (New)*		
HLF-3Ns	GWD/BMP	Downgradient well for New Ash Landfill
HLF-3Nd	GWD/BMP	Downgradient well for New Ash Landfill
HLF-4N	GWD/BMP	Downgradient well for New Ash Landfill
Coal Pile		
HCP-4	BMP	Upgradient well for Coal Pile
HCP-6	BMP	Downgradient well for the Coal Pile
Process Ponds		
HWW-4	/CAP	Downgradient well for WW Holding Basins
HWW-7	BMP	Downgradient well for Evaporation Pond
HSW-1	BMP/CAP	Downgradient well for Storm Water
Plant Site		
HPS-1	BMP	Downgradient for Plant Activities
Fuel Oil Sump MW	BMP	Downgradient for Fuel Oil Sump
Research Farm		
NH1W	GWD/BMP	Downgradient for Research Farm
NH2W	GWD/BMP	Lower Research Farm
NH3W	GWD/BMP	Lower Research Farm
NH4W	GWD/BMP	Mid-Research Farm/Downgradient of Duck Pond Drainage
NH5W	GWD/BMP	Mid-Research Farm
NH6W	GWD/BMP	Mid-Research Farm
NH7W	GWD/BMP	Upgradient of Research Farm
NH8W	GWD/BMP	Upgradient of Research Farm
NH-9W	GWD/BMP	Downgradient Research Farm
NH-10W	GWD/BMP	Upgradient of Research Farm
RG-1	GWD/BMP	Downgradient Research Farm
Surface Water Locations		
H-1	GWD/BMP	Upgradient Huntington Creek
H-2	GWD/BMP	Midpoint on Huntington Creek
UPL-9	GWD/BMP	Downgradient Huntington Creek
H-11	CAP	Spring
H-12	CAP	Duck Pond
NF-OLF	CAP	Downgradient of Old Landfill
SF-NLF	CAP	Downgradient of New Landfill
West End Canyon	CAP	Downgradient of Plant Activities
UPL-13	GWD/BMP	Routine Network for Research Farm
Landfill @	CAP	Downgradient of New Landfill

Potential Source Areas w/ Well IDs	Purpose	Justification
Pumphouse		
Duckpond @ Pumphouse	CAP	Downgradient of Old Landfill
Ck@DP3	CAP	Downgradient of old/new Landfill

BMP – Best Management Practice
CAP – Corrective Action Plan Monitoring
GWD – Ground Water Discharge Permit Monitoring
* - New Landfill CCR wells will be monitored until DWMRC begins regulating CCR Units.

Operational Monitoring Schedule

Operational monitoring at the Huntington Power Plant will be completed semi-annually for all ground and surface water locations for the monitoring points in **Table II**, except for Research Farm wells next to Huntington Creek (NH-3W, NH-6W, NH-8W and H8W) which will be sampled quarterly, until modified in writing.

Table III. Monitoring Frequency
Huntington Power Plant

Monitoring Location	Sample Frequency	Duration
Farm Wells away from Huntington Creek	Semi-Annual	Until Modified in Writing
Farm Wells Next to Huntington Creek	Quarterly	Until Modified in Writing
PSA Wells	Semi-Annual	Until Modified in Writing
Surface Water	Semi-Annual	Until Modified in Writing

Further detailed information on ground and surface water monitoring at the Huntington Power Plant can be found in the Ground Water and Surface Water Sampling and Analysis Plan included as Appendix E.

Appendix C

Discharge Minimization for the Old Combustion Waste Landfill and Contingency Plan

Overview

The preferred closure option for the Old Landfill area consists of leaving all combustion wastes in place and constructing an Evapotranspiration (ET) cover over all the material except the footprint of the industrial waste landfill, and Monitored Natural Attenuation (MNA). The cover has been designed and constructed to prevent water deposited on the surface of the cap from infiltrating into the combustion waste. The Sampling and Analysis Plan is focused on the ground water and surface water downgradient of the landfill area.

Reducing infiltration combined with monitored natural attenuation (MNA) is the preferred way to restore water quality.

1. Within the capped area, the expanded ET cap will eliminate the infiltration of precipitation into the landfill and eliminate run on from the surrounding terrain, thereby, allowing the existing liquid in the landfill to drain.

2. MNA is allowing PacifiCorp to track the ground water elevations and contaminant concentrations over time. If decreases in contaminant concentrations are not observed, then the industrial waste landfill will also be capped and the industrial waste landfill would be relocated. This monitoring allows PacifiCorp to document the effectiveness of the corrective action and to ensure protection of public health and the environment.

Contingency Plan

A set of contingencies will be implemented to ensure that future impacts to ground and surface water are eliminated. Following is **Table I**, which outlines the contingency plan actions if the corrective action plan does not completely address the impacts.

Table I. Contingency Plan Summary
Huntington Power Plant

Scenario	Contingency Action
New ET cap on Old Combustion Waste Landfill deteriorates.	1. Rehabilitation of cap in deteriorated areas.
Ground water/Surface water collection systems do not satisfactorily address contaminant issues.	1. Inspect systems to ensure proper operation. 2. Upgrade systems in any area(s) where problems are occurring. 3. Replace with alternative technology (pumpback systems) if necessary.
BMPs do not provide adequate reduction of New Combustion Waste Landfill seepage.	1. Evaluate dewatering process to pinpoint and upgrade problem areas. 2. Install pumpback system on the downgradient edge of New Landfill.
MNA does not adequately address ground water contamination issues.	1. Design and implement alternate ground and surface water treatment options.

Appendix D

Ground Water Discharge Permit
Permit No. UGW15002

PACIFICORP

HUNTINGTON RESEARCH FARM

WASTE WATER LAND APPLICATION PLAN

03
Revision

12/23/2015
Date

Bradley H. Giles
Prepared by

APPROVED:

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Darrell Cunningham – Managing Director, Huntington Plant

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Date

Appendix D
Huntington Research Farm
Waste Water Land Application Plan

1. Objective

The Huntington Research Farm was established on company owned property to dispose of plant waste water, as an efficient, cost effective and environmentally sound method to accomplish disposal.

The amount of water used on the Huntington Research Farm is carefully controlled to ensure that all the waste water is evaporated, absorbed by vegetation, or otherwise used so that no waste water escapes the company owned property into surface water or percolates through the soil and into the ground water system. This is accomplished by balancing environmental and weather information using sophisticated weather data and computer modeling through Utah State University and/or private consultant, by contract. The ground water system is monitored semi-annually using monitoring wells located in strategic places around the farm properties. This information is reported to the Utah Division of Water Quality semi-annually.

The Huntington Research Farm operates under the following set of objectives:

1. Dispose of power plant waste water by efficient agricultural irrigation within environmental regulations
2. Perform research and monitoring programs, which support the continued use of waste water in agricultural irrigation.
3. Operate the farm in the most economical and efficient manner possible.
4. Investigate revenue-generating options to reduce the operating cost of the Huntington Research Farm.

The Huntington Research Farm is composed of an estimated five different soil series with seven different soil types within these five different series (USDA et al. 1970). A complete text of each soil series and soil type are contained in **Appendix D.1**. The many different soil types pose a very complex challenge to uniform irrigation application and consistent crop growth over the field surface. Each soil series also offers a complicated set of water table and ground water problems. Water infiltration and holding capacities vary by soil type. Depth limitations and other problems with the soil profiles pose differing sets of problems for uniform irrigation application on the farm.

In order to comply with the first research farm objective, any crop that is grown must have a high water consumptive use, be salt tolerant, have a perennial growth habit, be deep rooted, and tolerant of elements contained in the waste water.

Alfalfa is grown on the largest amount of the acreage possible because of its deep root system, high water consumptive use factor, perennial growth habit, salt tolerance and high tolerance to boron. The choice for alfalfa is also supported by research conducted by Dr. John Hanks (Hanks, 1990), which showed that alfalfa yields are higher when irrigated with saline wastewater than when irrigated with fresh water. Small grains are used in a crop rotation with alfalfa for weed control and maximum nutrient utilization.

2. Procedure

2.1. Soil Moisture Determination

Field determination of the initial level of available moisture is essential where correct soil moisture control for high water use and efficient irrigation in the crop with no leaching is required. During the entire season, amount and frequency of irrigation should be varied in accordance with the actual moisture used by the crop during any growing period. At the beginning of the irrigation season, the soil moisture level should be known before staring irrigation. This is accomplished each spring; farm wide, by using the annual water balance information supplied by the evapotranspiration instrumentation and can be checked with the manual, "feel" method (**appendix D.2**) of soil moisture determination. This soil moisture information is used to give a starting point for irrigation requirements at the beginning of the irrigation season.

2.2. Actual Evapotranspiration (ET_a) Determination

A procedure to measure the amount of water lost from the soil surface through evaporation and the amount of water lost through transpiration from the crop canopy, evapotranspiration (**ET**) (**appendix D.3**), helps to determine the amount of water that is needed to be introduced, by irrigation, into the soil profile for continued crop production and maximum water utilization. The ET rate on the Huntington Research Farm is determined by using the Eddy Covariance instrument pack, installed in the middle of an alfalfa (Medicago sativa, L.) field on the lower Huntington Farm and an irrigated pasture with a mix of grass and alfalfa on the Huntington Rock Garden, with enough fetch to measure ET over the fields (500 foot radius from the station).

The watering rates at the Huntington Research Farm are carefully monitored and controlled to prevent surface runoff and deep percolation, so as to minimize impacts to surface water and ground water. In the water budget method, the moisture in the soil is regarded as being a balance between what enters it as a result of precipitation and irrigation, and what leaves through evapotranspiration. The budget becomes merely a balance of putting back into the soil, through irrigation, water that is lost through ET. This is achieved by irrigation at or below the reported daily ET_a rate.

2.3. Application Rates

Application rate of a sprinkler system is the rate at which water is applied, expressed in units of inch/hour. The Huntington sprinkler system is designed so that the average application rate over the irrigated area is less than the basic intake rate of the surface soil to prevent runoff. The design application rate for the Huntington Research Farm is 0.25 inches/hour. At this rate, approximately 2.78 inches of waste water is applied during an eleven hour set. Application rates per sprinkler head are estimated by size of the nozzle in the sprinkler head and the pressure at which it operates (**appendix D.4**).

2.4. Irrigation Frequency

Irrigation frequency refers to the number of days between irrigations. In practice, irrigation frequency is determined by means of water balance calculations, using available soil water capacity and the ET_a value calculated by the Eddy Covariance station.

Waste water irrigation frequency on the Huntington Research Farm is determined by using the daily ET_a rate over the previous days since last irrigation to get the total water usage from the available soil reservoir. When approximately 2.5 inches of water has been lost, as indicated by ET_a measurements, then an irrigation sequence is scheduled. The weather forecast is also taken into account so as to anticipate any potential precipitation events.

3. Controls

The primary control that is in place on the Huntington Research Farm to prevent surface runoff or leaching to ground water is the judicious application of the waste water in relation to ET_a measurements. The following measures are in place to handle the infrequent upset condition, or the unusual weather event, such as a 50 year storm.

3.1. Surface runoff

Each area of the farm is surrounded by an earthen berm that is used to channel any excess surface water to a retention pond. The ponds are of adequate size to contain a sprinkler system spill or system failure of up to 10 hours. These same ponds are designed to contain the surface runoff of a significant precipitation event. The intent of these ponds is that the bottoms would seal over time as water moved clay particles into the pore spaces. Water would then be lost through evaporation or by pumping into tank trucks.

Any surface spills that do enter waters of the State, are immediately reported to the State Division of Water Quality.

3.2. Ground Water

Ground water is protected from waste water contamination by careful control of the application of waste water from irrigation. By limiting the amount of waste water applied to a quantity less than the volume of water lost through evapotranspiration, the amount of water in the soil profile will not exceed the capacity of the soil and will not allow leaching into the shallow aquifers under the farm fields.

3.3 Sprinkler Spray

All sprinkler wheel lines that boarder Huntington Creek will have the following measures taken to eliminate possible over spray into Huntington Creek. All sprinkler heads on end caps of sprinkler lines that boarder Huntington Creek will have 180^{o} deflectors installed on the sprinkler heads. All end cap sprinkler heads will also use directional sprinkler heads. All Solid set sprinklers bordering Huntington Creek will use directional sprinkler heads.

4. Records and Reports

4.1. Irrigation Records

Knowing how much waste water has been applied to any area is essential to a successful waste water land application plan. An irrigation record is kept in the Huntington Research Farm office. Each sprinkler line is identified on the farm by its own name (**Appendix D.5**). The name contains the farm area where it is located (rock garden, east or west), the field name, and the direction locator (east, west, north, south or center). The number of risers available for each sprinkler line is also recorded. For each of these risers, there is a record of how many sprinkler heads are on the line for that riser setting (**Appendix D.6**). Each day the riser position of each sprinkler line on the farm that is running is recorded. The duration of the set is recorded daily. An example of the daily irrigation record sheet is contained in **Appendix D.7**. Knowing the number of sprinkler heads, the operating pressure and the length of time of the irrigation set, the volume of water applied for that area can be calculated. Using this number and the TDS value for the waste water, a rough estimate of the amount of salt applied can also be calculated.

4.2. Flow and Storage Records

The Huntington Farm uses three inline propeller type *Macrometer* flow meters to measure the gross amount of waste water delivered to each area of the farm. Flow is measured instantaneously in gallons per minute (gpm) and a totalizing meter measures total flow in acre feet (acft). One flow meter is located in the main water delivery line (mainline) before it branches to go to the two production areas of the farm and upstream of a line that gives the capacity to introduce fresh water into the waste water irrigation system. This first meter measures the flow of total waste water to the entire Huntington Farm before any fresh water is introduced. This fresh water line is metered with its own flow meter (Note: This fresh water line has not been used for over 20 years). The second flow meter is located in the lateral line just before the water enters a booster pump to deliver waste water to the rock garden area. It has the capacity to measure the gpm and total flow of water delivered, whether it is fresh water, waste water or a mix. A third meter is located in the lateral line that serves the lower farm, measuring gpm and the total flow, whether fresh or waste or a mix.

The present record keeping scheme has these three flow meters being read weekly by the farm. Waste water output to the irrigation storage reservoir (evap pond) by the power plant is recorded weekly also. This information is recorded by two flow meters located in a pump house servicing the two waste lines flowing from the Huntington Power Plant to the evaporation pond. The information from the three waste water irrigation flow meters and the two power plant waste water disposal lines is collected weekly by the farm. The data is forwarded to the farm manager. The manager takes the data and records the weekly irrigation rates for the two areas of the Huntington Farm and the amount of waste water added to the storage pond by the Huntington power plant. During the irrigation season an irrigation water sample is also taken from the evaporation pond. This sample is used to report the TDS and pH of the waste water. Weekly irrigation values and acres irrigated, by farm area are reported to ET Consultant to be compared against the actual ET (ET_a) curve for addition into the annual report from ET Consultant to PacifiCorp. The daily ET_a summaries are kept on file in the research farm office.

The actual level of waste water in the evaporation pond is also recorded weekly by reading the elevation off of staff gauges that are located in the pond. This data is used to calculate the amount of waste water that remains in storage in the evaporation pond. At the beginning of the irrigation season, this storage volume data is used to determine the number of acres that will be required to be irrigated on the farm, in order to dispose of all the waste water in an efficient manner and within environmental regulations. This data is also used weekly, as a gross check, of the flow meters, on the water balance of water out to the farm and water into the evaporation pond from the power plant.

4.3. Crop Records

Crop field records, indicating which crops were grown where, are recorded and saved. Crop inputs, such as seed, fertilizer and pesticides are also recorded.

4.4. Ground Water Report

Semi-annual ground water and surface water samples are collected. Spring samples are collected in late March or early April before waste water irrigation commences and the fall sampling is completed during late October or early November, as waste water irrigation is finishing or has been terminated. Results of these two sampling events are reported as required in the ground water permit. If any anomalies or exceedances are observed, they are indicated in the cover letter of the report.

4.5. Calculated Application Rate

The actual irrigation rate in inches of waste water applied will be calculated each week, combined with the weekly precipitation and compared with the measured actual evapotranspiration provided by the ET consultant. The farm manager will be responsible for this weekly evaluation and will prepare a report each month during the irrigation season to document the values. The report will be submitted to the environmental engineer. The report will contain the following:

a. Dates of each weekly period
b. Weekly flow quantity, totaled from the several flow monitors, in acre feet
c. Number of actively irrigated acres
d. Total precipitation during the week, in inches
e. Calculated irrigation rate, in inches
f. Total water applied, sum of irrigation and precipitation, in inches
g. Actual evapotranspiration amount for the week, in inches

h. Water balance calculation, in inches
i. Comments, e.g. estimated field moisture determinations, adjustments, etc.

The calculated irrigation rate will be determined by the following formula:

$$\text{Irrigation rate} = \frac{\text{Total gallons} \times 12}{\text{Acres irrigated} \times 7.481 \times 43{,}560}, \quad \text{inches}$$

The acres irrigated value is determined by the following formula:

$$\text{Acres irrigated} = \sum \frac{(N * SH * SR)}{43{,}560} \quad \text{for each irrigation line used}$$

N = number of sprinkler heads on the irrigation line
SH = spacing between sprinkler heads on the line, in feet, equals 40’
SR = spacing between the risers, in feet, equals 60’

The weekly water balance calculation will be found by taking the initial available soil moisture reading and subtracting the weekly ET_a sum and adding any irrigation and precipitation values. Subsequent water balance numbers are calculated by taking the previous week’s soil moisture number and adding the total water applied plus precipitation and subtracting the ET_a for the week to get a value in inches.

$$A_m = \sum ET_a - (I + P)$$

Where A_m = Available soil moisture, inches
ET_a = Sum of weekly actual evapotranspiration, inches
I = Irrigation amount, inches
P = Precipitation, inches

The precipitation and evapotranspiration rate are reported from the ET station instruments to the farm manager’s office every day with the previous day’s values.

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Appendix D.1 Soil Series and Types

Soils of the Hunting series are deep, gently sloping, and slightly to strongly saline. They are also medium textures and are somewhat poorly drained. These soils are alluvial fans and flood plains and in narrow alluvial valleys, where they have formed in alluvium that washed from marine shale and sandstone. The vegetation is mainly saltgrass or redtop grass, but greasewood grows in places. Elevations range from 4,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is between 47° and 54° F. The growing season ranges from 110 to 160 days.

In a typical profile, the surface layer is light brownish-gray, strongly calcareous loam about 9 inches thick. The underlying material is light brownish-gray and grayish-brown loam that contains a large amount of lime. Distinct mottles are at some depth between 20 and 40 inches.

The Hunting soils have a water table that is 20 to 40 inches below the surface. Most areas of Hunting soils are cultivated. Crops grown under irrigation are alfalfa, small grains, and sugar beets. Some areas are used for irrigated pasture.

Hunting loam (1 to 3 percent slopes) (Hn)**-** The profile of this soil is the one described as typical of the series. This soil generally occurs in areas of moderate size. The subsoil is mostly loam, but the texture below a depth of 40 inches ranges from clay loam to sandy loam. Typically, mottles are at a depth between 20 and 40 inches, but they are at a greater depth in places. Veins of gypsum are common, and the substratum contains 1 to 3 percent gypsum in most places.

Included in mapping were areas of soils that have a surface layer of silt loam, and other areas where the surface layer and subsoil are brown or dark brown. Also included were areas of Billings silty clay loam, areas of Rafael silt clay loam, and small spots of strongly saline-alkali soils.

Drainage is somewhat poor, and permeability is moderate. Roots penetrate deeply. Runoff is medium, and the hazard of erosion is moderate. This soil is easy to cultivate. About 12 inches of water is held by this soil, but only 5 inches of water is readily available to plants.

Seepage from irrigation canals and over irrigation of fields in higher areas contributes seepage water to these soils. Preventing seepage by lining irrigation canals and ditches and correct water application is less expensive and as effective at draining these soils. Excess water should be removed before these soils are used for crops.

Alfalfa, small grains, and sugar beets are grown under irrigation, but irrigated pasture is probably the dominant use because of the high water table. Alfalfa generally produces two full crops and a part of a third crop each year.

Soils of the Kenilworth series are stony, well drained, gently sloping to steep, and moderately coarse textured. They occupy high benches on old dissected outwash plains below very steep mountains along the western edge of the survey area. These soils have formed in a thick deposit of strongly to very strongly calcareous stony alluvium derived mainly from calcareous sandstone, quartzite, and limestone. The vegetation is mainly juniper and pinion. Elevations range from 6,000 to 7,200 feet. The annual rainfall is 8 to 12 inches, and the mean annual soil temperature is between 47° to 54° F. The frost-free season is 110 to 130 days.

In a typical profile, the surface layer is pale-brown, very strongly calcareous very stony sandy loam about 7 inches thick. The underlying material is pale brown and very pale brown stony sandy loam that is very strongly calcareous and contains 25 to 50 percent cobblestones and stones.

The Kenilworth soils are used for range. Some areas have been cleared for reseeding, but inadequate rainfall and stones on the surface prevent the success of such work in many places.

Kenilworth very stony sandy loam, 0 to 20 percent slopes, eroded (KeE2)**-** The profile of this soil is the one described as typical of the series. This soil occurs in large areas. Sheet erosion is active. Lime-coated gravel and cobblestones are on the surface in many places, and coatings of lime are on stones 2 to 6 inches above the surface. These lime-coated stones indicate that erosion has removed soil from around them. Gullies 2 to 3 feet deep are common in places.

This Kenilworth soil is well drained and is moderately permeable. Runoff is medium, and the susceptibility to erosion is slight to moderate. The root zone is shallow or moderately deep. Depth of root penetration is restricted by limy layers and stones. This soil retains about 4.5 inches of water, but only about 3.5 inches of water is readily available to plants.

This soil is used mainly as spring and fall range. Deer use it also for winter range. In places, juniper is cut for fence posts.

Mixed alluvial land (Mx)**-** consists of unconsolidated alluvium that is typically stratified and widely variable in texture, color, and consistence. It occurs along stream channels and in most places has been deposited recently by streams. This material is subject to change through periodic overflow, but it has remained in place long enough for plants to have become established. Typically, there has been no development of a soil profile, but in places the soil material near the surface is slightly darkened by organic matter. Drainage generally is restricted, and the soil material is mottled. Small areas in which the material is cobbly or stony are near the mouths of canyons. Away from the canyons, the sediments are finer textured.

This miscellaneous land type has little value for farming, except that it is used for grazing.

The Penoyer series consists of well-drained, calcareous soils that are medium textured. These soils occupy medium to large areas of alluvial fans, flood plains, and alluvial plains on the bottoms of canyons. They have formed in alluvium from sandstone, limestone, and basic igneous rocks. The natural vegetation is mainly sagebrush, Indian ricegrass, galletagrass, and shadscale. Elevations range from 4,000 to 6,5000 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is 47° to 54° F. The frost-free season is 110 to 160 days.

In a typical profile, the surface layer is light brownish-gray, strongly calcareous loam about 9 inches thick. The underlying material is light brownish-gray loam and very fine sandy loam.

Nearly all areas of Penoyer soils have been cleared and are planted to crops. The soils are used mainly for alfalfa, small grains, corn, sugar beets, melons, and irrigated pasture. Where air drainage is favorable for reducing the frost hazard, these soils are used for apple orchards.

Penoyer loam, 1 to 3 percent slopes (PeB). -The profile of this soil is the one described as typical of the series. The subsoil is typically loam or very fine sandy loam. Below a depth of 40 inches, this soil is weakly stratified with clay loam to sandy loam. In places gypsum veining and olive colors are below a depth of 3 to 4 feet.

Included in the mapping were small areas of Penoyer silt loam and Penoyer silty clay loam, and small areas of olive-brown or brownish-gray soils. Other inclusions consist of few areas that are underlain by gravel and in the bottoms of canyons. In some places soils are included that have slopes of slightly less than 1 percent.

Drainage is good, and permeability is moderate. Roots penetrate deeply. This soil retains about 12 inches of water, but only about 5 inches of water is readily available to plants. Runoff is medium, and the susceptibility to erosion is moderate. This soil is easy to work and to irrigate. It has the highest natural fertility of any soil in the survey area, and it is most responsive to management. Land leveling is needed in a few areas. The frost-free season is 110 to 130 days in 3 out of 4 years.

This soil is used for spring and fall range and for irrigated pasture, alfalfa, small grains, corn, and sugar beets. Because of the short growing season, alfalfa produces only two full crops and sometimes part of a third crop each year. Corn does not mature for grain and is used for ensilage.

Penoyer loam, 3 to 6 percent slopes, eroded (PeC2),**-** This soil is similar to the one for which a profile is described as typical of the series, except that it has stronger slopes and is eroded. Included in mapped were minor areas of gravelly soils and of soils similar to Penoyer, except that they have an olive or brownish-gray color.

Runoff is medium, and the susceptibility to erosion is high. Sheet erosion is moderately active. Many areas contain rills and shallow gullies.

This soil is used for irrigated pasture, alfalfa, and small grains. Many areas are used for spring and fall range.

Penoyer very fine sandy loam, 3 to 6 percent slopes, eroded (PsC2), **-** This soil is similar to the one for which a profile is described as typical of the series, except that it is steeper, has a coarser textured surface layer, and is eroded. It occupies alluvial fans, generally near the bases of mesas.

Included in mapping were areas, less than one-half acre in extent, of fine sands that are shallow over shale and sandstone.

Runoff is medium, and the susceptibility to erosion is high. Many areas are dissected by a few deep gullies. Hummocks 6 to 12 inches high occur in areas used for range. The available water capacity is about 7.5 inches.

This soil is used mainly for spring and fall range. Some areas, however, are used for irrigated grain and alfalfa or mixtures of alfalfa and grass.

Stony alluvial land (St) **-** consists of extremely stony alluvium from a variety of sedimentary rocks. It is mainly on the flood plains of live and ephemeral streams, but it also occurs on mud rock flows adjacent to the flood plains. The texture ranges from sandy loam to loam. Gravel, cobblestones, and other stones 3 inches to 4 feet in diameter make up 25 to 80 percent of the soil material. The content of the stones and cobblestones varies significantly within a few feet.

The present vegetation is scattered juniper trees, galletagrass, rabbitbrush, and some big sagebrush.

Appendix D.2: Manual "Feel" Method for Field Moisture Determination

This method of determining soil moisture levels is fairly accurate when applied on medium textured soils (silt loams or silty clay loams). Table 2 and Table 3 set forth the interpretation of the visual examination or "feel" method. Soil moisture information throughout the soil root zone profile is necessary for evaluating overall moisture conditions. When using the visual examination method, soil samples should be taken with an auger or probe at 8", 16" and 24" depths. Samples should be taken at several locations in each field for the most reliable information.

There are three conditions of moisture in the soil. They are referred to as the basic soil moisture relations. They are saturation, field capacity and wilting range. Saturation is defined as the amount of water that can be held in the soil when all air space in that soil is completely occupied by water (conditions when free water can be found when boring into the soil). Field capacity is defined as the amount of water a soil will hold against drainage by gravity (capillary water). Wilting range is defined as the range between the moisture content in a soil when plants begin to wilt and that moisture content when plants permanently wilt.

Table 2 Practical Interpretation Chart for Soil Moisture
USDA – Soil Conservation Service

Percent of useful soil moisture remaining	FEEL OR APPEARANCE OF SOILS			
	Coarse	Light	Medium	Heavy
0	Dry, loose, single-grained flow through fingers.	Dry, loose, flows through fingers	Powder, dry, sometimes slightly crusted but easily breaks down into powdery condition.	Hard, baked, cracked, sometimes has loose crumbs on surface
50 or less	Still appears to be dry; will not form a ball with pressure*.	Still appears to be dry; will not form a ball*.	Somewhat crumbly but will hold together form pressure.	Somewhat pliable, will ball under pressure*.
50 to 75	Same as Coarse texture under 50 or less	Tends to ball under pressure but seldom will hold together	Forms a ball*, somewhat plastic; will sometimes slick slightly with pressure	Forms a ball; will ribbon out between thumb and forefinger.
75 to field capacity	Tends to stick together slightly, sometimes forms a very weak ball under pressure.	Forms weak ball, breaks easily, will not slick	Forms a ball and is very pliable; slicks readily if relatively high in clay.	Easily ribbons out between fingers; has a slick feeling.
At field capacity	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand.	Same as coarse.	Same as coarse.	Same as coarse.
Above field capacity	Free water appears when soil is bounced in hand.	Free water will be released with kneading.	Can squeeze out free water.	Puddles and free water form on surface.

*Ball is formed by squeezing a handful of soil very firmly with fingers

Table 3 Soil Moisture and Appearance Relationship Chart

(This chart indicates approximate relationships between field capacity and wilting point)

Moisture Deficiency In./ft.	SOIL TEXTURE CLASSIFICATION Coarse (Loamy Sand)	Sandy (Sandy Loam)	Medium (Loam)	Fine (Clay Loam)
	(field capacity)	(field capacity)	(field capacity)	(field capacity)
.0	Leaves wet outline on hand when squeezed.	Appears very dark, leaves wet outline on hand, makes a short ribbon.	Appears very dark, leaves a wet outline on hand, will ribbon out about one inch.	Appears very dark, leaves slight moisture on hand when squeezed, will ribbon out about two inches.
.2	Appears moist makes a weak ball.			
.4		Quite dark color, makes a hard ball.	Dark color, forms a plastic ball, slicks when rubbed.	Dark color, will slick and ribbons easily.
.6	Appears slightly moist, sticks together slightly.	Fairly dark color, makes a good ball.	Quite dark, forms a hard ball.	
.8	Dry, loose, flows thru fingers. (wilting point)	Slightly dark color, makes a weak ball.	Fairly dark, forms weak ball.	Quite dark, will make thick ribbon, may slick when rubbed.
1.0		Lightly colored by moisture, will not ball.		Fairly dark, makes a good ball.
1.2			Slightly dark, forms weak ball.	Will ball, small clods will flatten our rather than crumble.
1.4		Very slight color due to moisture (wilting point)	Lightly colored small clods crumble fairly easily.	Slightly dark, clods crumble.
1.6				
1.8			Slight color due to moisture, small clods are hard. (wilting point)	Some darkness due to unavailable moisture. Clods are hard, cracked. (wilting point)
2.0				

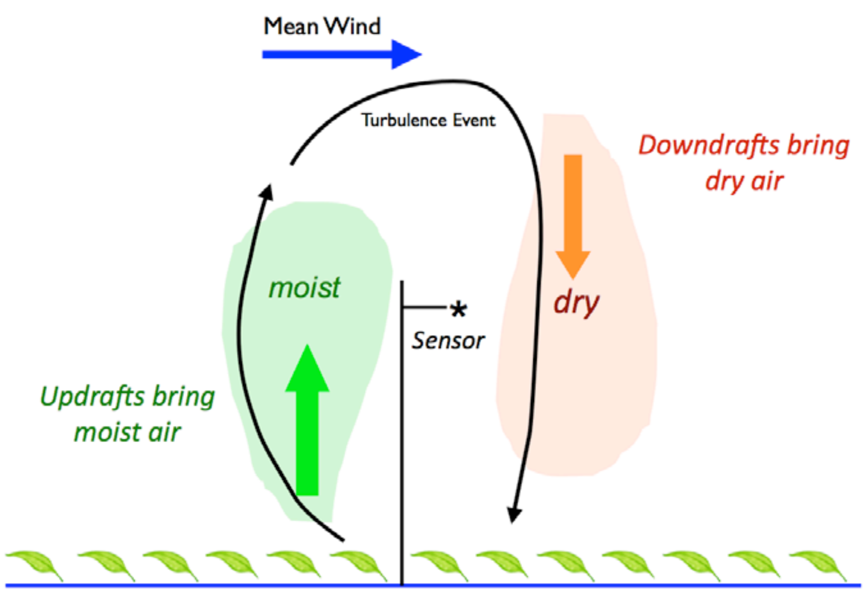
(McCulloch, 1976)

Appendix D.3: Actual Evapotranspiration (ET_a) Determination

Eddy covariance is the most direct way to measure the fluxes of mass and energy between the surface and atmosphere. Today, it constitutes the most scientifically credible and reliable method to determine various surface exchanges including evapotranspiration (ET) for a variety of different ecosystems (see for example: Baldocchi 2003; Aubinet et al., 2012). As such, it is the only methodology accepted for current research grade observation networks including: the CO_2 exchanges in terrestrial ecosystems (fluxnet.ornl.gov), the Integrated Land Ecosystem-Atmosphere Processes Study (http://www.ileaps.org), and the National Ecological Observation Network (http://www.neoninc.org).

Although the proper implementation and analyses involved in high quality eddy covariance calculations can be rather technical, the basic premise is fairly simple. It is turbulence in the lower atmosphere that actually transports properties of interest to and from the surface. Such a flow will exhibit episodes or gusts of upward motions and downward motions, at various time and space scales. If these updrafts and downdrafts are correlated with the property of interest, then they are acting to move it up or down.

An example would be the flux of water vapor from a vegetated surface (ET). As the air flows over a field, updrafts will be carrying moist air from near the surface, while downdrafts will bring down drier air from above. A simplistic, but useful diagram for this is illustrated below.



The vertical transport of humidity will be determined by how strongly the turbulence motions and the humidity correspond to one another. This is mathematically defined by the covariance determined over a proper averaging period. So the flux of water vapor or ET can be defined by:

$$E = cov\ (U_z, \rho_v)$$

where U_z is the vertical wind, ρ_v is water vapor density of the air, and cov is the covariance over the time period. Likewise, flux of CO_2 can be determined from:

$$F_c = cov\ (U_z, \rho_c)$$

Here, ρ_v is the CO_2 density of the air. So if measurements are made above a surface, as the wind blows the turbulence fluctuations past the sensors, this covariance can be measured. To capture the small-scale motions, a rapid sampling rate of 10 to 20 Hz (times per second) is required. In addition, the averaging period must be chosen to match the properties of the turbulence.

Implementation of the technique requires a 3-dimensional sonic anemometer, and a fast-response humidity/CO_2 sensor. It turns out that a suite of other corrections and analyses are also required, but are not discussed here.

Although considerable expertise is required for eddy covariance measurements and subsequent analyses, it represents the most scientifically credible method to estimate fluxes of mass and energy for a variety of surfaces. It remains the most credible methodology for cutting edge research into these processes.

Weather and evapotranspiration data are gathered automatically by the Farm's computer each night. Transmissions occur using cellular communication between 1:00 a.m. and 4:00 a.m. This modem is connected to a radio that calls the two Huntington Research Farm evapotranspiration stations**.** The data are transferred back to the office computer as an answer. These data are transferred to the ET consultants office in the early morning for daily quality control and processing. The office computer processes the data utilizing the Eddy Covariance equations and provides a daily and hourly weather summary for the ET station, printed automatically daily, as well as a monthly weather and ET summary for the station. The daily and hourly summary is available early in the morning for the coming day. This daily summary provides a single actual evapotranspiration (ET_a) value, measured in inches/day, for the previous 24 hour period.

During short periods when some sensors are not functioning properly, procedures developed in previous years are used to estimate the missing data required for computation of ET. For instance, missing global or net radiation data can be created using the linear relationship between these two parameters during the many years of data collected at the specific station.

The water balance equation and other equations required for computations of actual (ET_a, based upon the Eddy Covariance) and potential (ET_p) evapotranspiration.

The water balance at the surface (all terms in $mm \cdot time^{-1}$) is:

$$I + P = \pm LE \pm \Delta S \pm R \pm D \qquad [A1]$$

where I is irrigation, P is precipitation, LE is positive for evapotranspiration and negative for deposition (dew or frost), ΔS change in the soil moisture content (positive for depletion and negative for repletion), R is surface runoff (positive when water goes out and negative when comes in), and D is deep percolation (positive when water leaves the root zone and negative when water comes to the root zone from underneath).

The energy balance at the surface (all terms in $W.m^{-2}$) is:

$$\pm R_n = \pm LE \pm H \pm G \qquad [A2]$$

where R_n is net radiation, and LE(+ for evapotranspiration), H(+ for warming of the air), and G(+ for warming of the top soil) are latent, sensible and the top soil heat fluxes, respectively.

The Bowen-ratio, β is:

$$\beta = H / (LE) = C_p\, d\theta / (L\, dq) \qquad [A3]$$

The potential temperature, θ, in K is:

$$\theta = T(1000 / P)^{0.286} \qquad [A4]$$

The specific humidity, q, in $kg\ kg^{-1}$ is:

$$Q = 0.622\, e_a / (P- 0.378\, e_a) \qquad [A5]$$

The actual vapor pressure, e_a, in mb is:

$$E_a = 6.1121 * EXP\ [17.502\, T_{dew}, °C / (240.97 + T_{dew}, °C)] \qquad [A6]$$

The pressure, P, in mb is (assuming a dry adiabatic lapse rate of 10 °C/km):

$$P = 1013\, \{[288 – 0.01\ 9altitude, M)] / 288\}^{3.416} \qquad [A7]$$

The latent (LE) and sensible (H) heat fluxes are:

$$LE = (R_n – G) / (1 + \beta) \qquad [A8]$$

and

$$H = \beta\, (R_n – G) / (1 + \beta\,) = \beta\, LE \qquad [A9]$$

The potential evapotranspiration, ET_p, in $MJ\ m^{-2}\ d^{-1}$ is:

$$ET_p = [\Delta / (\Delta + \gamma)](R_n – G) + 6.43\{[\, \gamma / (\, \Delta + \gamma\,)](\, e_s – e_a\,)(1.0 + 0.014u_2)\} \qquad [A10]$$

Where R_n and G are in $MJ\ m^{-2}d^{-1}$, $e_s – e_a$ is in kPa (1 kPa = 10 mb), and u_2 is in $km\ d^{-1}$

The slope of saturation vapor pressure-temperature, Δ , in kPa °C^{-1} is:

$\Delta = 4098e_s$,kPa / (T,°C + 237.3)^2 [A11]

The saturation vapor pressure, e_s, in mb is:

E_s = 6.1121 * EXP[17.502 T,°C / (240.97 + T,°C)] [A12]

The psychrometric constant, γ, in kPa °C^{-1} as:

$\gamma = C_p$.P, kPa / (0.622L) [A13]

The latent heat of vaporization, L, in J kg^{-1} as:

L = 2500800 – 2366.8T,°C [A14]

The relative humidity, RH, in % is:

RH = 100(e_a / e_s) [A15]

Note:

The specific heat of air at constant temperature, C_p, is 1004 J $kg^{-1}K^{-1}$. Evapotranspiration, ET_a, in m d^{-1} can be computed using the computed latent heat (LE) in J m^{-2} d^{-2} divided by L p_v, where L is in J kg^{-1} and p_v = 1000 kg m^{-3} is the water density.

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Appendix D.4: Standard Nozzle Performance*

Nominal stream height 7' above nozzle** @ normal pressure

Nozz. Dia.	1/8"		9/64"		5/32"		11/64"	
Nozzle PSI	GPM	Dia. Ft.	GPM	Dia. Ft.	GPM	Dia. Ft.	GPM	Dia. Ft.
50	3.18	83	4.07	85	4.98	90	6.01	95
55	3.34	84	4.27	86	5.22	91	6.30	96
60	3.48	85	4.46	87	5.45	92	6.57	97
65	3.63	86	4.55	88	5.68	93	6.83	98
70	3.76	87	4.83	89	5.60	94	7.09	99
75	3.90	88	5.00	90	6.11	95	7.34	100
80	4.02	89	5.17	91	6.30	96	7.58	101

*All sprinklers were tested under minimum wind conditions. The water pressure readings were taken below the sprinkler inlet to provide meaningful design data. All pressure readings recorded are accurate to within 2% of actual pressure. The recorded flow rate (in U.S. gallons per minute) is accurate to within 1% of actual flow.

**Standard Nozzle at mid-point of pressure range

(Weather·Tec, 1999)

Appendix D.5: Sprinkler Line Identifying Names

Huntington Research Farm

Description (Name)	Abbreviation
East Farm	
Barn East	EBE
Barn Center	EBC
Barn West	EBW
Cottage	EC
Front Pasture East	EFPE
Front Pasture West	EFPW
West Farm	
Office	WO
Research North	WRN
Research South	WRS
Pump House	WPH
Duck Pond	WDP
Homestead	WH
Alfalfa	WA
Bull Pasture North	WBPN
Bull Pasture South	WBPS
Research Plot	WRP
Rock Garden	
Rock Garden 1 South	RG1S
Rock Garden 1 North	RG1N
Rock Garden 2 South	RG2S
Rock Garden 2 North	RG2N
Rock Garden 3 South	RG3S
Rock Garden 3 North	RG3N
Rock Garden 4 South	RG4S
Rock Garden 4 Center	RD4C
Rock Garden 4 North	RG4N

Appendix D.6: Sprinkler Head Count per Line

Huntington Research Farm Riser and Sprinkler Heads

LINE	Total Riser	1	2	3	4	5	6	7	8	9	10	11	12	13
EBE	9	18	18	18	18	18	15	15	13	11				
EBC	9	21	21	21	21	21	21	16	14	14				
EBW	9	10	10	10	10	10	10	10	10	10				
OFFICE	11	33	33	33	33	31	31	29	29	27	27	25		
RN	10	10	10	10	10	10	10	10	10	10	10			
RS	10	18	18	18	16	16	14	14	14	12	10			
PH	12	26	26	26	26	26	25	23	23	21	21	21	21	
DP	13	21	21	21	21	21	19	19	17	17	15	12	9	
WA	12	22	22	22	22	22	23	23	23	24	19	19	16	16
BPN	6	29	29	29	29	29	29							
BPS	6	28	28	28	24	22	20							
RG1S	7	12	12	11	11	10	10	10						
RG1N	7	15	15	15	13	13	11	11						
RG2S	7	26	26	26	26	26	26	26						
RG2N	6	31	31	31	31	31	31							
RG3S	7	30	30	29	28	28	27	27						
RG3N	7	22	22	22	22	21	20	20						
RG4S	7	31	32	33	35	39	39	39						
RG4C	7	39	39	39	39	39	39	39						
RG4N	7	28	28	29	30	31	32	33						
FPE	4	11	17	11	29									
FPW	2	15	6											
HSTD	12	13	11	10	8	8	7		6	5	4	4	4	
ECTG	1	18												
PLOT	1	23												

Appendix D.7: Irrigation Record Sheet

Huntington Research Farm

Enter riser number of the sprinkler set into the portion of the cell for the date in use

Month - **Date-**

Description (name)			Mon -1	Mon -2	Mon-3	Tue-1	Tue-2	Tue-3	Wed-1	Wed-2	Wed-3	Thu-1	Thu-2	Thu-3	Fri-1	Fri-2	Fri-3	Sat-1	Sat-2	Sat-3
Lower Farm																				
Barn East	EBE	9																		
Barn Center	EBC	9																		
Barn West	EBW	9																		
Office	WO	11																		
Research North	WRN	10																		
Research South	WRS	10																		
Pump House	WPH	12																		
Duck Pond	WDP	12																		
Alfalfa	WA	13																		
Bull Pasture North	WBPN	6																		
Bull Pasture South	WBPS	6																		
Rock Garden																				
Rock Garden 1 South	RG1S	7																		
Rock Garden 1 North	RG1N	7																		
Rock Garden 2 South	RG2S	7																		
Rock Garden 2 North	RG2N	6																		
Rock Garden 3 South	RG3S	7																		
Rock Garden 3 North	RG3N	7																		
Rock Garden 4 South	RG4S	7																		
Rock Garden 4 Center	RG4C	7																		
Rock Garden 4 North	RG4N	7																		
Handlines and Solid Set Sprinklers																				
Front Pasture East	EFPE	4																		
Front Pasture West	EFPW	2																		
Homestead	WH	12																		
Cottage	EC	1																		
Research Plot	WRP	1																		
System Pressure	psi																			
TDS - (weekly)	ppm																			
River sprinkler check, Days																				
River sprinkler check, Afternoons																				

Flow Meters

Read Flow Meters Monday Mornings

Pit ______________ **#1** ______________

River ______________

Rock Garden ______________ **#2** ______________

Staff Guage ______________

#3 ______________

Signature

Morning ______________________________

Afternoon ______________________________

Application rate and volume equations

Total volume of wastewater delivered per sprinkler head

$$H_t = V_n * (60 * (T))$$

Where H_t = Total volume delivered by sprinkler head in one set, gallons
V_n = Water volume delivered for 5/32 inch nozzle, gallons per minute (gpm), equals **6.3** gpm
T = Total time of sprinkler set, hours
60 = 60 minutes/hour

Total volume of wastewater delivered per sprinkler line

$$V_t = S_n * H_t$$

Where V_t = Total volume delivered by sprinkler line in one set, gallons
S_n = number of sprinkler heads on line at riser set S
H_t = Total volume delivered by sprinkler head in one set, gallons

Total area sprinkler by one sprinkler head

$$A_s = W_s * L_s$$

Where A_s = Area sprinkled per sprinkler head, square feet (ft^2)
W_s = Width of set, feet (ft), equals **60** ft
L_s = Length of set, ft, (distance between heads) equals **40** ft

Total area sprinkled by one sprinkler line per set, square feet

$$T_a = A_s * S_n * L_s$$

Where T_a = Total area sprinkled by one sprinkler line, ft^2
A_s = Area sprinkled per sprinkler head, square feet (ft^2)
S_n = number of sprinkler heads on line at riser set S
L_s = Length of set, ft, (distance between heads) equals **40** ft

Total area sprinkled by one sprinkler line per set, acre

$$T_{at} = \frac{T_a}{A_f}$$

Where T_{at} = Total area sprinkled per set, acre (ac)
T_a = Total area sprinkled by one sprinkler line, ft^2
A_f = Square feet per acre foot, equals **43,560** ft^2/ac

Total volume of wastewater delivered per sprinkler line, acre feet

$$AF_v = \frac{V_t}{V_{af}}$$

Where AF_v = Total volume applied per sprinkler line, acre feet (acft)
V_t = Total volume delivered by sprinkler line in one set, gallons
V_{af} = Gallons (gals) per acft, equals **325,827** gals/acft

Total water applied per acre, acre feet per acre (acft/ac)

$$T_{af} = \frac{AF_v}{T_{at}}$$

Where T_{af} = Total water applied per acre, acft/ac
AF_v = Total volume applied per sprinkler line, acre feet (acft)
T_{at} = Total area sprinkled per set, acre (ac)

Total Water Applied per acre, acre inches per acre (acin/ac)

$$Tai = Taf * In$$

Where Tai = Total water applied per acre, acin/ac
T_{af} = Total water applied per acre, acft/ac
In = inches per foot, equals **12**, in/ft

Appendix E
Ground Water & Surface Water Sampling and Analysis Plan Huntington Power Plant

1.0 INTRODUCTION

This Sampling & Analysis Plan (SAP) is written to: 1) provide descriptions of existing monitoring locations; 2) describe sample parameters and frequency; 3) provide the Quality Assurance/Quality Control (QA/QC) requirements for the water monitoring at the Huntington Power Plant that meets State of Utah and RCRA Subtitle D regulations; and, 4) properly document all sampling procedures and sampling data.

The SAP is written to satisfy the monitoring requirements of the Ground Water Discharge Permit (permit No. UGW150002).

1.1 Responsible Person

Implementation of the Sampling and Analysis Plan at the Huntington Power Plant is the responsibility of the Plant's Environmental Engineer.

1.2 Corrective Action

Corrective actions may occur during the implementation of this SAP. Any changes in the sampling schedule, sampling forms, sample locations, choice of laboratory, parameters, standard operating procedures (SOP's), and methods will be documented and explained. The sampling personnel and the Huntington Power Plant Environmental Engineer are responsible for the implementation, documentation, and evaluation of the corrective actions.

2.0 GROUND WATER & SURFACE WATER MONITORING PLAN

Currently, the ground and surface water sampling conducted at the Huntington Power Plant is part of the Site-Wide Monitoring Plan.

- **Ground Water Discharge Permit**: The specific requirements of the discharge permit are incorporated into this SAP to monitor, track, and document compliance with the discharge permit.

The monitoring at the facility includes ground water and surface water monitoring. The ground water monitoring points are sampled for water level, field parameters, and laboratory parameters. All surface water monitoring points are monitored for field parameters, and laboratory parameters, select points will also be monitored for flow.

2.1 Monitoring Network

2.1.1 Ground Water

The monitoring system consists of ground water sampling in the area of the Old Landfill, the plant site, waste water facilities, coal pile and the Research Farm. Ground water monitoring is conducted through sampling of monitoring wells (Table III & Figure 3). The monitoring wells are located downgradient of the old landfill, along the Duck Pond Drainage, the plant site, waste water facilities, coal pile and on the Research Farm Property. Field and analytical parameters are listed in Table II.

2.1.2 Surface Water

The surface water monitoring locations are along the Duck Pond Drainage, upgradient on Huntington Creek, above the farm on Huntington Creek, irrigation storage reservoir and downgradient of the farm on Huntington Creek.

All water sample locations will be monitored for the constituents shown in Table II.

Table II. Field & Analytical Monitoring Parameters

Field Measurements		
Water Level	pH	
Temperature	Specific Conductance	
Analytical Data		
Analyte	**Method**	**Detection Limit**
Total Dissolved Solids	E160.1/A2540C	10 mg/l
Sodium	E273.1/E200.7/E200.8	1 mg/l
Potassium	E258.1/E200.7/E200.8	1 mg/l
Magnesium	E242.1/E200.7/E200.8	1 mg/l
Selenium	E200.8	0.002 mg/l
Calcium	E215.1/E200.7/E200.8	1 mg/l
Sulfate	E300.0	1 mg/l
Alkalinity	E310.1/A2320B	5 mg/l
Carbonate	A2320B	5 mg/l
Bicarbonate	A2320B	5 mg/l
Chloride	E300.0/A4500CLB	1 mg/l
Nitrate + Nitrite	E353.2	0.1 mg/l
Boron	E200.7/E200.8	0.01 mg/l

Table III lists the wells and surface water locations included in the water monitoring plan for the Huntington Power Plant facility. All existing monitoring locations are shown in Figure 3.

Table III. Monitoring Locations
Huntington Power Plant

Potential Source Areas w/ Well IDs	Purpose	Justification
Ash Landfill (Old)		
LF-1O	CAP/BMP	Upgradient well for Old Ash Landfill
LF-2O	CAP/BMP	Downgradient well for Old Ash Landfill
LF-3O	CAP/BMP	Upgradient well for Old Ash Landfill
LF-4O	CAP/BMP	Downgradient well for Old Ash Landfill
LF-6O	CAP/BMP	Downgradient well for Old Ash Landfill
LF-7Od	CAP/BMP	Downgradient well for Old Ash Landfill
Ash Landfill (New)*		
HLF-3Ns	CAP/BMP	Downgradient well for New Ash Landfill
HLF-3Nd	CAP/BMP	Downgradient well for New Ash Landfill
HLF-4N	CAP/BMP	Downgradient well for New Ash Landfill
Coal Pile		
HCP-4	BMP	Upgradient well for the Coal Pile
HCP-6	BMP	Downgradient well for the Coal Pile
Plant Site		
HFOS-mw	CAP	Downgradient well for historic oil spill
HPS-1	BMP	Downgradient well for Plant
Process Ponds		
HWW-4	BMP	Downgradient well for Wastewater Decanting Basins and Drying Pad
HWW-7	BMP	Downgradient well for Evaporation Pond
HSW-1	BMP	Downgradient well for Drying Pad
Research Farm		
NH1W	GWD/BMP	Downgradient for Research Farm
NH2W	GWD/BMP	Lower Research Farm
NH3W	GWD/BMP	Lower Research Farm
NH4W	GWD/BMP	Mid-Research Farm/Downgradient of Duck Pond Drainage
NH5W	GWD/BMP	Mid-Research Farm
NH6W	GWD/BMP	Mid-Research Farm
NH7W	GWD/BMP	Upgradient of Research Farm
NH8W	GWD/BMP	Upgradient of Research Farm
NH-9W	GWD/BMP	Mid-Research Farm
NH-10W	GWD/BMP	Upgradient of Research Farm
RG-1	GWD/BMP	Downgradient for Research Farm
Surface Water Locations		
H-1	GWD/BMP	Upgradient Huntington Creek
H-2	GWD/BMP	Midpoint on Huntington Creek

Potential Source Areas w/ Well IDs	Purpose	Justification
UPL-9	GWD/BMP	Downgradient Huntington Creek
H-11	CAP	Spring
H-12	CAP	Duck Pond Surface
Drain-O	CAP	Downgradient of Old Landfill
Drain-N	CAP	Downgradient of New Landfill
West End Canyon	CAP	Downgradient of Landfill
UPL-13	GWD/BMP	Routine Network for Research Farm
Landfill @ Pumphouse	CAP	Downgradient of Landfill
Duck Pond @ Pumphouse	CAP	Downgradient of Landfill
HG-FD	CAP	Downgradient of Landfill
Creek at DP3	CAP	Downgradient of Landfill

BMP – Best Management Practice
CAP – Corrective Action Plan Monitoring
GWD – Ground Water Discharge Permit Monitoring
* - New Landfill CCR wells will be monitored until DWMRC begins regulating CCR Units.

2.2 Operational Monitoring Schedule

Operational monitoring at the Huntington Power Plant will be completed semi-annually for all ground water wells and surface water locations for the monitoring points in Table III, except for Research Farm wells next to Huntington Creek (NH-3W, NH-6W, NH-8W and H8W) which will be sampled quarterly, until modified in writing.

Table IV. Monitoring Frequency
Huntington Power Plant

Monitoring Location	Sample Frequency	Duration
Farm Wells, away from Huntington Creek	Semi-Annual	**Until Modified in Writing**
Farm Wells, next to Huntington Creek	Quarterly	**Until Modified in Writing**
PSA Wells	Semi-Annual	**Until Modified in Writing**
Surface Water	Semi-Annual	**Until Modified in Writing**

2.3 Post-Operational Monitoring Schedule

In order to tailor post-operational monitoring plans to adequately monitor ground water conditions at the site, a post-operational monitoring schedule will be determined by the State of Utah and Huntington Power Plant personnel as plant closure approaches. At that time, the State of Utah and Huntington Power Plant personnel will also determine post-operational monitoring points and sampling frequency.

2.4 Reporting Requirements

Semi-annual reports describing all water sampling, static water level measurements, and a summary of surface water data will be submitted to the State of Utah-Division of Water Quality and the Huntington Power Plant. Analytical results of each sampling event, inspections and maintenance, and any well construction activities, and any recommendations concerning modifications to the sampling frequency, analytical constituents or monitoring network will be submitted to the State of Utah-Division of Water Quality and Huntington Power Plant with the ground water monitoring reports.

Copies of all Field Log Books used for water monitoring must be retained. The field records must be available for UDEQ. Field Log Books will be comprised of detailed notes, forms and narratives documenting site sampling conditions and procedures to demonstrate the SAP and QA/QC Plan are being followed. Variances from the SAP will be documented and explained in the field notes. Records will be archived until the project is inactive plus five years. All data will be maintained in electronic format.

2.5 Monitoring Well Network Maintenance

2.5.1 Monitoring Well Inspections

Monitoring well inspections will be conducted and the results reported on the ground water sampling form. Ground water sampling personnel will inspect each well whenever sampling or monitoring activities are conducted. Wells will be inspected for the integrity of the locking cap, padlock, and steel well protector, and PVC well casing riser and cap.

Any foreign material removed from a well during purging or sampling activities will be described.

Monitoring well inspections will be recorded in the Field Log Book during each monitoring event.

2.5.2 Monitoring Well Inspection Reports

Any breach of integrity observed by the ground water sampling personnel will be reported to the Huntington Power Plant Environmental Engineer. If for any reason a well is destroyed or otherwise fails to function properly or its integrity is determined to be breached, the Huntington Power Plant Environmental Engineer will coordinate well repair or replacement.

2.5.3 Monitoring Well Abandonment

If the damage to or integrity of the well cannot be repaired, the well may be recommended for and properly abandoned and replaced within 180 days unless otherwise approved in writing by the State of Utah.

Well abandonment procedures are as follows:

1. Break bottom cap with a spear;
2. Pump well full of bentonite grout with a packer to force injection of grout into formation;

3. Let well sit for 24 hours;
4. Refill with grout (if necessary); and
5. Remove surface completion (if possible).

A well log report fully describing all abandonment procedures will be submitted to the State of Utah within 90 days of the abandonment activity.

2.5.4 Installation of Replacement Wells

Replacement wells, if needed, will be installed at locations which allow them to fulfill the intended purpose of the well they are replacing. Wells will be installed and completed as specified in Section 2.5 of this report. The Huntington Power Plant Environmental Engineer and his consultants, in conjunction with the State of Utah, will determine the exact well locations.

The replacement well will be developed and sampled upon installation. Following the initial sampling event, the well will be included and sampled in accordance with the established schedule for all other ground water monitoring network wells.

2.5.5 Documentation of Well Construction

If a major plan or report, including semi-annual reports of ground water monitoring activities, is in preparation at the time of new well construction, development or rehabilitation, the lithologic log, well construction logs, and other well construction and development details will be attached as an appendix to the major document. Otherwise, replacement well construction documentation will be submitted to the State of Utah within 90 days.

3.0 WATER SAMPLING & ANALYSIS PLAN

3.1 Objectives

The objective of this SAP is to provide detailed procedures, which are to be followed during all sampling events scheduled at the Huntington Power Plant.

3.2 Sampling Personnel

Experienced PacifiCorp personnel will conduct the routine monitoring, as needed.

3.3 Water Monitoring Locations

The locations of existing sampling locations at the Huntington Power Plant are shown in Figure 2.

3.4 Water Monitoring Parameters

A summary of the field and analytical data to be collected during each sampling event is detailed in Section 2.1, Table II.

3.5 Sampling Schedule

Ground and surface water sampling will be conducted semi-annually except for Research Farm wells next to Huntington Creek (NH-3W, NH-6W, NH-8W and H8W) which will be sampled quarterly, with reporting on a semi-annual basis. A certified laboratory will conduct laboratory analysis. Semi-annual reports and accompanying lab sheets will summarize all ground and surface water sampling results.

3.6 Safety

It is the sampler's responsibility to obtain, maintain, and operate all equipment in a safe manner during a sampling event. The sampler's personal safety and that of any persons who accompany the sampler must be the primary concern at all times and in all sampling situations. A sampler who encounters a condition that may exceed the protection of their safety equipment or represent a potential hazard to human health should leave the area immediately and contact the Huntington Power Plant Environmental Engineer. Safety equipment may include but is not limited to:

- Safety glasses;
- Hard hat;
- Safety boots;
- Gloves;
- Cell phone;
- Protective clothing.

3.7 Sample Labeling and Shipping

Each sample sent to the laboratory must be labeled on the container in permanent, waterproof marking pen able to withstand long-term exposure to water. The label identification must cross-reference to the chain-of-custody form and the sampler's Field Log Book.

Sample labeling must identify four elements:

1. Day of the year;
2. Time;
3. Sample ID code; and
4. Name or chemical formula of the preservative used.

3.8 Waste Disposal

Solid and liquid wastes generated by field sampling will be disposed of in a proper manner. Any non-hazardous liquid will be disposed of at the sampling site. Solid waste products will be disposed of at an approved waste collection facility.

4.0 QUALITY ASSURANCE/QUALITY CONTROL PLAN

Activities required to produce accurate, precise, and repeatable results are an integral part of field sampling activities and laboratory analytical procedures.

4.1 Field Quality Assurance/Quality Control Plan

A QA/QC Plan depends on meticulous attention to detail and documentation by field personnel. Field sampling personnel are responsible for following standard operating procedures for equipment calibration and decontamination, well monitoring, sample collection including QA/QC samples, sample preservation, labeling, storage, and transportation to the analytical laboratory. All activities must be documented with care to verify correct handling and to permit accurate reporting of results.

4.1.1 Field Sampling Procedures

Field sampling procedures will include the following:

1. Equipment maintenance;
2. Equipment decontamination;
3. Equipment calibration;
4. Sample collection and preservation;
5. Sample storage and handling; and,
6. Field documentation of sampling activities.

4.1.1.1 Equipment Maintenance

Sampling equipment must be properly maintained. Table V lists sampling equipment maintenance procedures.

Table V. Equipment Maintenance

Equipment:	**Procedure:**
Solinst (or equivalent)Water Level Meter & Graduated Tape	Clean after each field use; Wash with mild detergent; and Rinse well, Replace 9-volt battery when the auditory or visual signal weakens or fails.
Horiba Water Quality Checker U-10, U-52 or equivalent	Rinse thoroughly after each field use; For longer storage, fill the small rubber cap with water and use it to cover the pH sensor. If storage is for a prolonged period (>6 months), remove the battery from the main unit.

4.1.1.2 Equipment Decontamination

All equipment, which comes in contact with ground water, will be decontaminated prior to use in a new sampling area. Table VI lists sampling equipment decontamination procedures.

Table VI. Equipment Decontamination

Equipment:	Procedure:
Solinst (or equivalent) Water Level Meter & Graduated Tape	Wash with mild detergent or (alcanox) and a brush; Rinse with tap water; and Air dry.
Horiba Water Quality Checker U-10, U-52 or equivalent	<u>Turbidity sensor</u> Wash out the tube using tap water; And Rinse with tap water. Do not use abrasives or cleaners. <u>Conductivity sensor</u> Wash out using tap water and rinse with tap water.

4.1.2 Field Documentation Procedures

A Field Log Book or Data Sheets will be maintained and prepared prior to the sampling event. Sufficient details including, but not limited to, those listed below will be included to document and permit reconstruction of all sampling events without relying on memory. The records will be completed in waterproof ink and will be legible and complete. The Field Log Book will be a compendium of forms pertinent to the specific field activity. More than one Field Log Book may be in use at one time; however, information will be recorded in only one of the logbooks to prevent duplication or omission of information, except for that required to adequately cross-reference other information.

The first page in the Field Log Book will contain

- Name of Facility

For each site visit or sampling event, the following information will be provided:

- Date(s) of sampling;
- Names of persons sampling;
- Weather conditions;
- Field activities conducted and their purposes;
- Sample collection time;
- Sample ID;
- Description of the condition, if not normal, of the protective casing, well casing, and annular seal; and
- Initials of person providing the information.

The Field Log Book will be specific to each field event and will be a compendium of forms pertinent to that specific field activity or time period. The Field Log Book for ground water sampling events will include:

- Map of sample locations at the Huntington Power Plant;

- Ordered list of sampling activities;
- Chain-of-custody Record; and.
- Field Data Sheets and Notes

4.1.3 Field Equipment Calibration

Calibration procedures are specific to each instrument. At a minimum the Horiba (or equivalent) will be calibrated before each sampling day and the Solinist will be calibrated annually or after repairs. Table VII lists sampling equipment and its calibration procedures.

Table VII. Equipment Calibration

Equipment:	**Calibration Procedure:**
Solinst Water Level Meter & Graduated Tape	Power instrument, as probe is held vertically or horizontally 10-20 ft from cable reel, use a steel tape graduated in 0.01 ft increments to measure distance from the tip of the probe to the sensor level, the sensor to the 1 ft mark on the graduated portion of the tape, & the sensor to the 10 and/or 20 ft mark on the graduated portion of the tape. Calculate calibration correction factor (if necessary).
Equipment:	**Auto-Calibration Procedure:**
Horiba Water Quality Checker U-10, U-52 or equivalent	Fill the calibration beaker 2/3 with standard solution, fit the probe over the beaker, turn power on, press MODE key which puts unit into MAINT mode, check that lower cursor is in the AUTO sub-mode, press ENT key and the readout shows "CAL", after a few minutes the upper cursor will cycle through all calibration parameters, and when complete, "End" will show briefly and then return to the MEAS mode.

4.1.4 Chain-of-Custody Procedures

A chain-of-custody record supplied by the analytical laboratory will be completed for all samples as they are collected. The record will include or be similar to, depending on the laboratory requirements:

- The project name and number;
- Name of the analytical laboratory destination;
- Sampler’s signature;
- Sample identification number, date and time of collection;
- Number of containers and type of sample;
- Analysis requested and number of containers provided per analysis; and
- Any special instructions or hazard warnings.

When sampling is complete, the samples will be packed for transport. A completed chain-of-custody will be enclosed in a Ziploc bag, placed inside the cooler. The samples will then be ready for shipping or delivery. Upon delivery, both parties to the exchange will sign and date the record noting the time of the exchange of custody. The sampler will be the first relinquishing signature and the laboratory personnel will be the final receiving signature. Intermediate signatures may or may not be present.

4.2 Sample Acquisition Methods

The sampling procedures described herein are designed to obtain representative ground water and surface water samples from the Huntington Power Plant.

Ground Water

Depth to water or static water level measurements will be collected during each sampling event. If previous sampling data is available, and sample collection proceeds from the well with the lowest concentration of TDS to the well with the highest concentration of TDS, decontamination is only required between PSA,s. Otherwise, decontamination is required between each well. Before being placed in each monitoring well, the water level probe will be decontaminated by rinsing the end of the probe with distilled water. Depth to water will be measured in each monitoring well. This will allow the calculation of static ground water elevations for approximately the same time period.

To ensure that a representative sample is collected at each sampling location, the following sampling steps will be followed at each location. Sampling steps in order of performance at each well include:

- Transport all appropriate equipment to the sampling site;
- Inspect well;
- Don disposable gloves;
- Determine depth to water;
- Calculate water column volume;
- Purge well (three well volumes);
- Measure field parameters during purge and at the end of full purge;
- Withdraw sample;
- Field filter (as required); and
- Containerize/preserve sample aliquots.

If a well is purged dry prior to removing three well volumes, that well will be allowed to recover and then sampled. A note of explanation will be included in the Field Log Book. If past data shows the well will not recover in 24 hours, purge a small amount, then collect sample.

Surface Water

Surface water samples will be collected at locations shown on Figure 3. Grab samples from surface water bodies will be acceptable at the Huntington Power Plant.

- Transport all appropriate equipment to the sampling site;
- Don disposable gloves;
- Measure field parameters ;
- Withdraw sample;
- Field filter (if required); and

- Containerize/preserve sample aliquots.

In order to ensure reproducible sample data, surface water sample points will be clearly marked or located with GPS coordinates.

4.2.1 Well Inspection

In accordance with Section 2.5.1, the protective casing will be examined for damage during each monitoring event. The padlock and cap will be inspected and then removed. The riser casing and cap will also be inspected for damage. Observed odors will be noted. Detailed notes of any damage ascertained will be recorded in the Field Log Book.

4.2.2 Determine Static Water Height

Static water level measurements will be taken at each monitoring well sampled. The steps are as follows:

1. Locate well and note general condition in Field Log Book;
2. Unlock casing and uncap monitor well;
3. Don clean disposable sample gloves;
4. Measure and record (±0.01 ft) static water level in Field Log Book;
5. Calculate volume of well water to be removed and record in Field Log Book;
6. Cap and lock well if not sampling immediately; and
7. Rinse water level probe with distilled water.

4.2.3 Well Purging

Well purging will be performed at each monitoring well sampled. The steps are as follows:

1. Purge minimum of 3 well volumes or until well is purged dry,
2. Record total volume of water removed in Field Log Book;
3. Record observations of purged water; and
4. Properly dispose of purge water.

4.2.4 Surface Water Discharge Measurements

Select gauging station near sample site H-1, H-2, and UPL-9. Location should have a uniform channel shape and flow should be as uniform as possible. Location should not have the possibility of bypass and should not be located downstream of any in-stream structures such as bridges.

Cold weather conditions, when sampling personnel must be in the water must be minimized and periods when ice has built up or is breaking up will be avoided, as well as periods of high flows due to rapid precipitation or snow melt

Samples and measurements will be collected semi-annual to coincide with the groundwater sampling schedule of April and October.

1. Extend Tape across channel and measure total channel width (w).
2. Divide the channel into one foot equal sections (b).
3. Collect velocity readings (v) in the horizontal center of each stream segment at 60% of the total depth (d).
4. Record the stage reading from each location.
5. Record all measurements in a field notebook.

4.2.5 Sample Withdrawal

Sample withdrawal procedures are as follows:

1. Don disposable gloves;
2. Label bottles using waterproof marker;
3. Lower bailer or pump to collect ground water samples, add preservatives (if required) to the sample bottle;
4. Collect sample for field parameters;
5. Measure and record field parameters;
6. Withdraw sample and fill all sample bottles;
7. Check all sample bottle caps for tightness;
8. Place sample in cooler for on-site storage and transport to the lab;
9. Record sample ID, location, well ID, date, time, and other observations in Field Log Book;
10. Rinse all equipment with distilled water; and
11. Cap and lock well.

4.2.6 Sample Containerization, Preservation, and Holding Times

Each sample parameter has a specific container requirement, volume requirement, preservative, and maximum holding time. Table VIII lists sample containerization, preservation, and holding times.

Table VIII. Sample Containerization, Preservation, & Holding Times

Parameter	Container Plastic (P) Glass (G)	Minimum Volume (ml)	Preservative	Maximum Holding Time
Alkalinity	P or G	250*	ice	14 days
Boron	P or G	250*	ice	28 days
Calcium	P or G	250*	ice, unpreserved	6 months
Chloride	P or G	250*	none required	28 days
Metals, except those specifically listed	P or G	500**	ice, nitric acid (HNO_3) to pH 2	6 months
Nitrate-Nitrite	P or G	250*	ice, sulfuric acid (H_2SO_4) to pH 2	28 days
pH	P or G	250*	none required	analyze immediately
Sodium	P or G	250*	ice, unpreserved	6 months
Specific Conductance	P or G	250*	none required	analyze immediately
Sulfate	P or G	250*	ice	28 days

Reference: *Energy Laboratories Analytical Services, 1998

4.2.7 Field Parameter Measurement

The calibration and field parameter measurements will be documented in the Field Log Book.

1. Don disposable gloves;
2. Lower bailer or pump to collect ground water samples;
3. Place sample in container large enough to accommodate Horiba;
4. Record field parameters, pH, specific conductivity and temperature, in field log book;
5. Cap and lock well if not sampling immediately; and
6. Rinse Horiba probe with distilled water.

4.3 Shipping and Handling

Sampling personnel will retain custody of the samples or assure their integrity between the time of collection and delivery to the analytical laboratory. Table VIII will be consulted to ensure that samples were properly preserved and submitted within the allowable holding times. Coolers will be packed with ice to ensure they are received with an acceptable cooler temperature of 4ºC. Any transfer of custody will be recorded on the chain-of-custody record. Chain-of-custody procedures are presented in Section 5.2.

4.4 Analytical Parameters

The site-specific monitoring parameters for Huntington Power Plant are shown in Section 2.1, Table II.

5.0 LABORATORY QUALITY ASSURANCE/QUALITY CONTROL PLAN

5.1 Laboratory Identification

A certified and accredited laboratory will analyze the ground water monitoring samples from the Huntington Power Plant.

5.2 Sample Custody

When accepting custody of the samples, laboratory personnel record them in the sample receipt log and give each container a unique sample-tracking number. Samples that are preserved by the sample collector are checked for proper preservation. Laboratory personnel will check the chain-of-custody for accuracy. If samples are improperly preserved or the maximum holding time has been exceeded, the sampler is notified and re-sampling is requested.

5.3 Analytical Turn-Around Time

Analytical turn-a-round time is dependent on the number of samples awaiting analysis and/or by arrangement with the sampler. All samples are analyzed within the holding time period for the specific method. Water quality sampling analysis holding times are different for each individual parameter and are shown in Section 4.2.6, Table VIII.

5.4 Calibration Procedures and Frequency

Analytical laboratories follow instrument and equipment manufacturer's calibration instructions and EPA, ASTM or other published method procedures. Initial instrument calibration curves are generated, verified and routinely monitored by continuing calibration checks throughout the duration of all instrumental analysis. When possible, the laboratory uses certified stock calibration standards. Standard preparation notebooks document the source, purity, content, concentration, data and analyst.

Samples are only quantitated within the limits of the response of the calibration standards. Volumetric dilution of high concentration samples is used to bring sample analyte concentrations within the calibration range. Calibrations may occur more frequently as indicated by instrument maintenance activities or out-of-control conditions.

5.5 Data Reduction, Validation and Reporting

Data reduction refers to the process of converting raw data to reportable units. Whenever possible, the analytical instrument is calibrated to read out directly in the reporting units and the values are recorded directly into a laboratory notebook or logbook and onto the raw data forms for review. In cases where calculation is required prior to reporting, raw data is recorded in the appropriate laboratory notebook and on the appropriate laboratory form. In this case, the calculations specified in the method are used to determine the reported value, which is also entered in the laboratory notebook and on the draft of the client report. Most of the calculations are computerized to reduce the potential for arithmetic or transcription errors.

Data validation includes procedures to ensure that the reported values are consistent with the raw data and the calculated values.
The data recorded on the draft laboratory report is validated with four steps:

1. The analyst, who submits the report, checks all reported values for omissions and accuracy.
2. The report is reviewed and necessary data reduction is performed by the supervisor.
3. The reports are typed, proofread and reviewed by the word processing staff.
4. The manager or his designee examines the validity of the data and the final report.

One copy of the report is mailed to the client on the day the data is reported and one copy is filed in the separate client file maintained at the analytical laboratory.

5.6 Internal Quality Control Checks

The Quality Control Program at the analytical laboratory includes a demonstration of laboratory capability, a demonstration of the analyst's ability, the analysis of quality control samples and the maintenance of performance records.

Laboratory glassware conforms to National Bureau of Standards (NBS) Class A standards. All mechanical pipetors are calibrated monthly. Distilled and deionized water are used in laboratory analyses. For each procedure, water quality is monitored for acceptability. Chemical reagents and gases are purchased from reliable sources. Laboratory stock and working standards are derived from commercially available primary standards and solvents whenever possible.

Analytical Equipment Standard Operating Procedures (AESOPs) have been developed for each major piece of equipment and instrumentation. The AESOPs detail the sequence of operations involved in instrument start-up, calibration, analyzing and shutdown. AESOPs also include recommended schedules for routine preventative maintenance and identify those parameters, which dictate other types of maintenance. Acceptable instrument response/performance criteria are based upon the manufacturer's analytical method specifications.

Analytical Method Standard Operating Procedures (AMSOPs) have been developed by the laboratory for well-detailed EPA, ASTM and published procedures. Qualified personnel capable of performing each method are on staff at the analytical laboratory. It is the responsibility of each analyst to become thoroughly familiar with methodology and instrument operation before performing the analysis. The performance of each analyst is monitored during the training period by a supervisor until the analyst demonstrated the ability to generate results of acceptable accuracy and precision as required by each method.

Quality control monitoring requires that five to ten percent of all samples analyzed be fortified (spiked) with a known concentration of the analytes stipulated by the method. Percent recovery is calculated as a means of monitoring method accuracy. Where appropriate, the use of surrogates is included in the method to monitor method performance on each sample. The method may also require duplicate samples to be prepared and analyzed when possible. When duplicate samples are analyzed, relative percent difference is calculated and used to monitor precision of the method. In the instances where there are no specific method requirements, it is the policy of the laboratory to analyze five to ten percent of all samples in duplicate. Matrix Spike duplicates replace duplicates for certain methods. Continuing calibration checks of the established calibration curves are included for the appropriate methods.

All quality control monitoring is recorded on the appropriate quality control form, graph or chart as required by the individual AESOPs. This data is filed and is available for internal inspection and assessment.

5.7 Performance System Audits

The Quality Assessment program at the analytical laboratory includes performance evaluation samples, quality control check samples and quality control audits.

Performance Evaluation (PE) samples are supplied by an outside agency and contain known amounts of constituents. Typically the analyst does not have access to the known values prior to the analysis. Results of the PE analyses are sent to the outside agency for evaluation. Established procedures must be followed regarding the timeliness of analysis and the return of results.

Quality Control (QC) reference samples may come from a commercial source or may be prepared in-house as required by the specific method. QC samples are processed through the system in the same manner as any other sample.

The analytical laboratory conducts internal Quality Control Audit inspections on a quarterly basis to monitor adherence to quality control requirements. Samples, which have been previously submitted and reported, are chosen at random for the audit. The audit checks general laboratory operations, adherence to QA program goals, sample tracking procedures, holding times, storage requirements, adherence to procedures during analysis, calculations, completion of required quality control samples within the group surrounding the sample, and proper record keeping. The audit results are reported to management personnel with recommendations for corrective action if any discrepancies are found. A follow-up audit is conducted to determine that problems have been corrected.

5.8 Records and Reporting

The laboratory maintains several different kinds of notebooks, including but not limited to: project notebooks, instrument/equipment use and maintenance logbooks, standard preparation logbooks, sample receipt logbooks, and a safety logbook. The general purpose of maintaining each of these notebooks is to record the activity details, which may be pertinent to repeating a procedure, interpreting data or documenting certain operations. It is the responsibility of each analyst to maintain a laboratory notebook. The analyst's notebook is particularly important in documenting analyses, which deviate in any way from routine or standard practices.

Records of chemical analyses including all quality control records are kept by the laboratory for a minimum of five years. The records include chain-of-custody forms, sample submittal and analysis dates, person responsible for performing analyses, analytical technique/method used, results of analysis, quality control results, laboratory notebooks, electronic instrument data files, and a copy of the final report.

Corrective action is taken when quality control checks indicate that an analysis is not within the established control limits. The appropriate corrective action is dependent on the specific method and/or instrument. If a duplicate or spike analysis fails to fall within control limits, the analysis is repeated to verify that a problem exists. If the repeated analysis is not within control limits, the instrument and/or method procedure is checked according to specific protocols outlined in the AESOP and/or AMSOP. Once results are within control limits, analysis of all samples that were analyzed while the procedure was out of control is repeated. If the analyst is unable to achieve acceptable results after following the guidelines detailed in the AESOP and/or the AMSOP, supervision may determine that the instrument requires repair, or it is possible that the problems cannot be corrected to satisfy QC criteria. If all possible solutions are examined and the sample results appear to be valid, comments are attached to the sample report describing the non-compliance to QC and the probable cause. If a QC audit or other informational review shows an analysis report to be incorrect or incomplete, a written corrected report is submitted to the client with details of the correction, an explanation of the error and an assessment of the accuracy of the amended report.

5.9 Method Detection Limits and Instrument Detection Limits

Method Detection Limits (MDLs) will be calculated and reported by the analytical laboratory for each applicable analytical instrument and procedure. The MDL is defined as the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. The MDL is determined from analysis of a sample in a given matrix containing the analyte. It is based on a specific, well-defined analytical method and is calculated from the results of seven or more replicate analyses of samples with analyte levels at or near the detection limit of the method. Typically MDLs are calculated using prepared samples in a relatively clean matrix. Instrument Detection Limits (IDLs) are similar to

MDLs, but are based on instrument detection limits independent of the method used to prepare the extract. Actual IDLs and MDLs may increase due to interferences found in samples and sample extracts. When MDLs are limited by analytical instrument sensitivity, IDLs are used to estimate MDLs.

6.0 DATA AND REPORTS

6.1 Data Entry

Data will be entered correctly, following established procedure for documenting and correcting data entry errors.

6.2 Data Archiving

The groundwater sampling data collected is required to be archived. Table IX lists data archiving details.

Table IX. Data Archiving

Data Item	Data Format Paper (P) Electronic(E)	Backup Copy & Format	Location	Retention Time
Chain-of-Custody forms	P	none	Huntington Power Plant, PacifiCorp	Inactive 5+ Years
Equipment calibration logs	P	none	Huntington Power Plant, PacifiCorp	Inactive 5+ Years
Field data sheets	P	none	Huntington Power Plant, PacifiCorp	Inactive 5+ Years
Field Log Books	P	none	Huntington Power Plant, PacifiCorp	Inactive 5+ Years
Laboratory test results	P & E	disk	Huntington Power Plant, PacifiCorp	Inactive 5+ Years
Spreadsheet	P & E	disk	Huntington Power Plant, PacifiCorp	Inactive 5+ Years
Statistical analyses	P & E	disk	Huntington Power Plant, PacifiCorp	Inactive 5+ Years
Final report	E	disk	Huntington Power Plant, PacifiCorp	Inactive 5+ Years
Photographs	P & E	disk	Huntington Power Plant, PacifiCorp	Inactive 5+ Years

6.3 Semi-annual Report

Reports will be written and submitted to the State of Utah, Division of Water Quality on a semi-annual basis. The contents will include all sampling and monitoring data as mentioned in Sections 2.1, 2.5.1, and 3.5. The reports will be a summary of ground water sampling activities conducted during each sampling event.

7.0 REFERENCES

National Handbook of Water Quality Monitoring, Natural Resources Conservation Services, May 1998.

Manual of Standard Operating Procedures for Sample Collection and Analysis, Wyoming Department of Environmental Quality, Water Quality Division, Watershed Program, March 2001.

National Oceanic & Atmospheric Administration (NOAA), 2000.

Huntington Power Plant-Ground Water Analysis Huntington Farms Report, Water & Environmental Technologies, August 2002.

Huntington Power Plant, 2004 Annual Monitoring Report and Site-Wide Investigation, Water & Environmental Technologies, August 2005.

Huntington Power Plant, 2005 Annual Monitoring Report, Water & Environmental Technologies, May 22, 2006.

Techniques of Water-Resource Investigations of the United States Geological Survey, Book A6, A7, A8, and A10, USGS 1976.

FIGURES

APPENDIX A
SAMPLING EQUIPMENT CHECKLIST

Ground Water Sampling Checklist

Monitoring Equipment

- ☐ Electronic Water Tape (Backup)
- ☐ pH Meter
- ☐ DO Meter
- ☐ SCT Meter
- ☐ Sample/Purge Pump
- ☐ Disposable Tubing
- ☐ Replacement Batteries

Decon Equipment

- ☐ Decon Buckets
- ☐ Mild Detergent
- ☐ Brush
- ☐ Distilled Water
- ☐ Sample Gloves

Miscellaneous Equipment

- ☐ Tool Box
- ☐ Well Keys
- ☐ Map
- ☐ Well List
- ☐ Last Round Water Levels
- ☐ Extra Bailers
- ☐ Bailer String

PPE

- ☐ Rain Gear
- ☐ Steel Toe Boots
- ☐ Safety Glasses
- ☐ Hardhat
- ☐ Cold Weather Gear

Sample Containers

- ☐ Sample Bottles and Preservative
- ☐ Coolers
- ☐ Plastic Bags
- ☐ Ice
- ☐ Permanent Marking Pens
- ☐ Field Book

Appendix F
Criteria to End Land Application of Waste Water

All soil-plant-salt-water systems have a self-regulating nature. The soil has a finite capacity for salt storage that is determined by plant sensitivity to salinity. No matter how little one irrigates, eventually the salt storage capacity of the soil is exhausted and the accumulated salt causes a yield reduction (in addition to any yield loss from water limitations). This salinity-induced yield loss results in a decrease in transpiration (or plant water uptake) and the water not used by the plant becomes drainage. Thus, leaching is inevitable. As long as water is the limiting growth factor, leaching may be prevented. But, when salt becomes the limiting factor, leaching must occur. The accumulating salt effectively shortens the root zone so that over time, fewer and fewer roots actively extract water.

The useful lifetime of the Huntington Research Farm will end when the crop plants cannot transpire all of the waste water. At that point, irrigation will produce leaching in violation of the Ground Water Discharge Permit, Permit No. UGW150002. PacifiCorp will need to watch for the accumulation of a reservoir of saline water in the lower reaches of the root zone that is not used up over the growing season.

Current protocols at the Huntington Research Farm include:

- Monitoring plant health, growth and yield. Data will be collected three times each growing season.
- Monitoring soil salt accumulation with depth, well below the root zone. Soil samples will be taken in the spring, annually.
- Monitoring soil moisture with depth, well below the root zone. Neutron probe data will be collected at least spring and fall.
- Monitoring potential and actual plant water use, evapotranspiration. Data is collected daily.

The combination of these observations allows us to determine if the plants are being unduly restricted in growth (and hence, water uptake), if salt and water are accumulating in the lower reaches of the root zone of each individual crop, and most importantly, if a persistent residual reservoir of un-transpired saline water is building up in the root zone.

If the latter condition (a buildup of unused saline water in the lower 25 to 50 cm of the crop root zone) were to occur and persist over two growing seasons, recommendations will be made for the discontinuance of waste water irrigation at the site. This criterion is integrative of the overall function of the system. It takes into account seasonal differences in plant growth, irrigation water salinity, the self-regulating dynamics of saline soil water movement in the profile, and the precipitation/dissolution dynamics of salt stored within the soil.

Monitoring data and results will be included in an annual report that will be filed in the Huntington Research Farm office for inspection.

Appendix G
Suitability of the Research Farm Land Application Site for Future Land Application

Dr. Grant Cardon, Professor and Extension Soils Specialist
Plants, Soils and Climate Department, Utah State University

<u>Introduction</u>

The research farm land application site located adjacent to PacifiCorp's Huntington power plant, has been in operation since the late 1970's. Saline wastewater from the plant is used to irrigate several forage grass varieties and alfalfa along-side paired plots irrigated with fresh water from Huntington Creek in an effort to guide the broader use of saline wastewater on other crop lands associated with the Huntington Power plant. The objective of the work at the research farm land application site is to monitor plant health and productivity as well as soil salinity and constituent salt ion content in soils, and water use patterns within the paired saline and fresh water irrigated plots. This information allows the tracking of changes over time in soil productivity affected by salinity, and observation of potential shifts in ion uptake that could adversely affect crop performance.

In 2011, protocols were established to serve as indicators of continued suitability of the research farm land application site. Specifically, these protocols are:

- Monitoring plant health, growth and yield.
- Monitoring soil salt accumulation with depth, well below the root zone.
- Monitoring soil moisture with depth, well below the root zone.
- Monitoring potential and actual plant water use, evapotranspiration.

Collectively, these data help determine if plants are being unduly restricted in growth (and hence, water uptake) thereby increasing the flow of water past the root zone and potentially affecting the leaching of salt ions to deeper depths in the soil profile. The primary indicators would be declining performance of crop production compared to fresh water irrigation and an accumulation of unused saline water well below the root zone of the crop.

The paired plots are set up in a line-source arrangement where two line sources (one saline and one fresh) are operated parallel to one another over areas planted perpendicular to the two line sources. The lines are separated by a distance sufficient to prevent overlap of the two irrigation waters. Therefore, water application from any given line-source is highest along the line and reduces with distance away from the line until no water is applied by irrigation to the cropped areas. A map of the current plot layout is included as Figure 1 below.

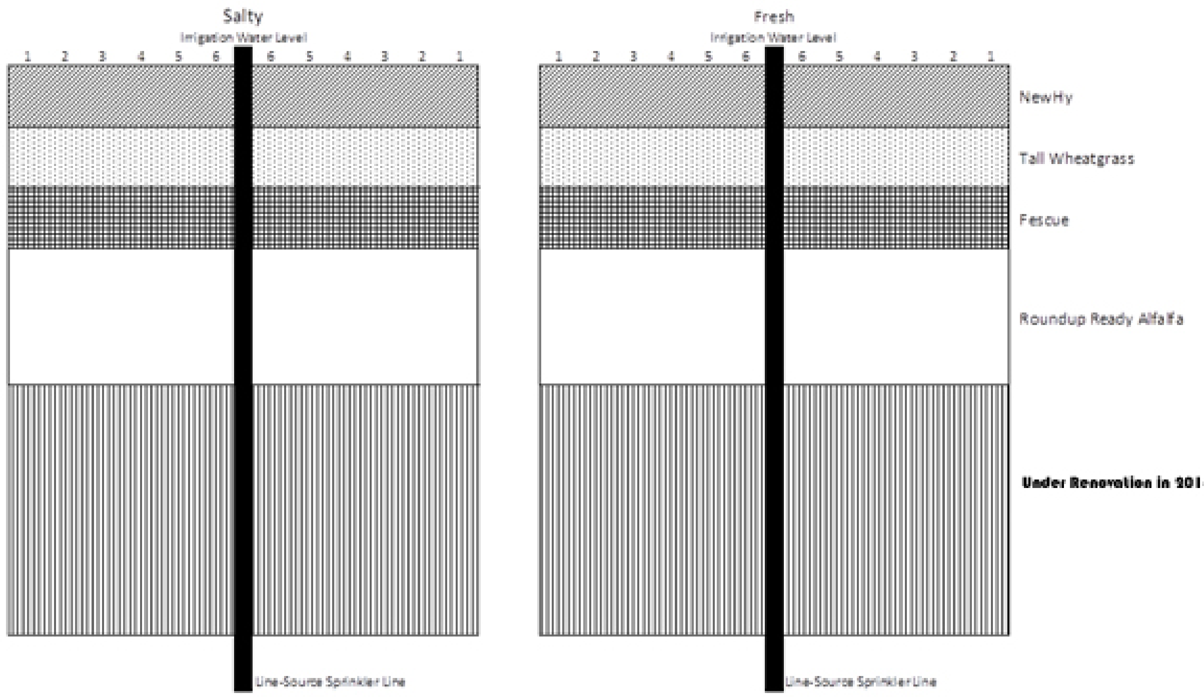


Figure 1. Huntington site plot map

In the arrangement shown in Figure 1, similar levels of water application amount are indicated by same-numbered water levels, with water level 6 being the highest amount applied, and water level 1 being just outside the coverage of the sprinkler line, thereby receiving no irrigation water. Water level 4 is designed to be the optimum water application level meeting crop water demand as dictated by daily determinations of potential and actual evapotranspiration calculated from a weather station operated by Utah State University and located on the Huntington Research Farm land application site.

Therefore, as designed, continued suitability of the research farm application site would be indicated by crop productivity in water levels 4 thru 6 being similar to and stable over time compared to counterpart plots under fresh water irrigation. Moreover, under water level 4 and below (down to level 1) there should be no accumulation of unused saline water below the root zone, and water extraction patterns should be similar to those in the paired fresh water plots.

This report will provide a summary of the current state of crop productivity (qualitatively using photographic evidence and quantitatively using direct yield measurements), measured water use patterns in the root zone and salt accumulation patterns in the root zone, as the means of determining continued, productive use of water from the soil at the land application site. For efficiency, data from the fescue grass plots and the alfalfa plots will be reported.

Crop Productivity

Qualitative/Photographic Record

Figure 2. Saline water (left) and Fresh water (right) irrigated fescue plots showing harvest strips taken perpendicular to the line-source sprinkler system.

Figure 3. Saline water (left) and Fresh water (right) irrigated alfalfa plots showing harvest strips taken perpendicular to the line-source sprinkler system.

Inspection of the photos shown in Figures 2 and 3 demonstrate the productive and comparable yield of crops under current conditions at the research farm land application site. Despite saline irrigation water being applied to plots at the site, no visual symptoms of specific salt ion toxicity or nutrient deficiency are observed on either the grass crops or alfalfa.

Quantitiative/Yield Measurements

Yield is taken several times each season and the dry weight of forage is determined at each cutting. Relative yield between paired salty and fresh water irrigated plots provides a normalized observation of performance. A salty:fresh yield ratio of 1.0 indicates that no reduction due to salinity accumulation is occurring. Moreover, even at a moderate yield deficit, the stability of the yield ratio is important. The stability of the yield ratio remaining steady over time indicates that there is no trend for decreased ability of the crop to take up water and nutrients under saline irrigation at the site. One of the criteria for discontinuing land application of wastewater at the research farm would be if there is indication of a decreasing trend in the salty:fresh yield ratio.

Figures 4 and 5 illustrate a yield comparison over an extended period of time (2007 to 2015). Due to the age of the crop stands, changes were made to renew the forage grasses and alfalfa plots to new stands of modern varieties. Grasses were renewed first in 2009 and 2010, and alfalfa was renewed in 2011 and 2012

By inspection of the data, comparable yields are being obtained from the grasses and alfalfa over time and between the salty and fresh plots at paired water levels 4 through 6. The small yield reduction at water level 4 illustrates the compromise of a reduction in irrigation amount to prevent leaching of salt ions, but provide sufficient water for near-maximum growth of the crop, which is the optimum designed management scenario for saline wastewater at the site, and the goal of water management at all other cropped sites associated with the Huntington Power plant.

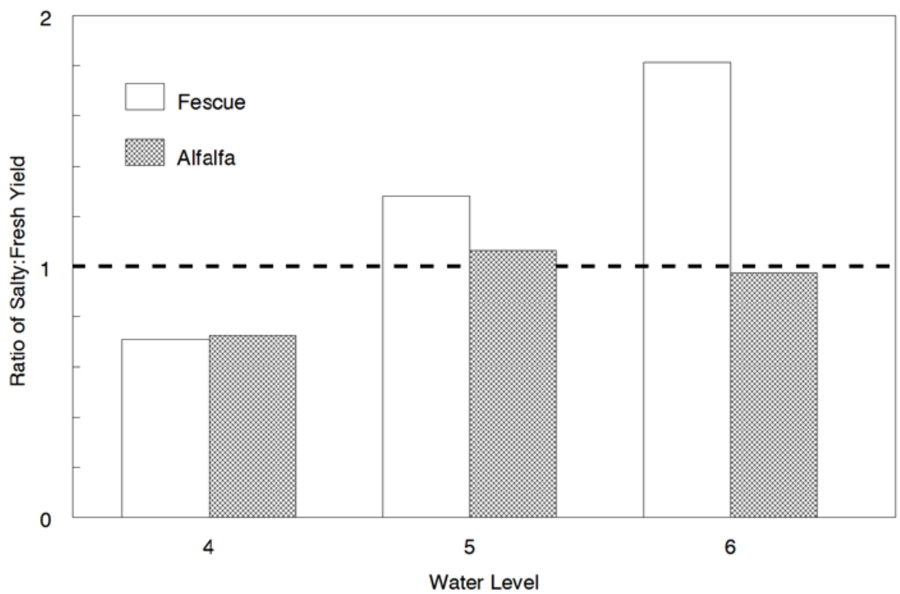


Figure 4. Yield ratio between salty and fresh plots for fescue and alfalfa for July 2015 cuttings.

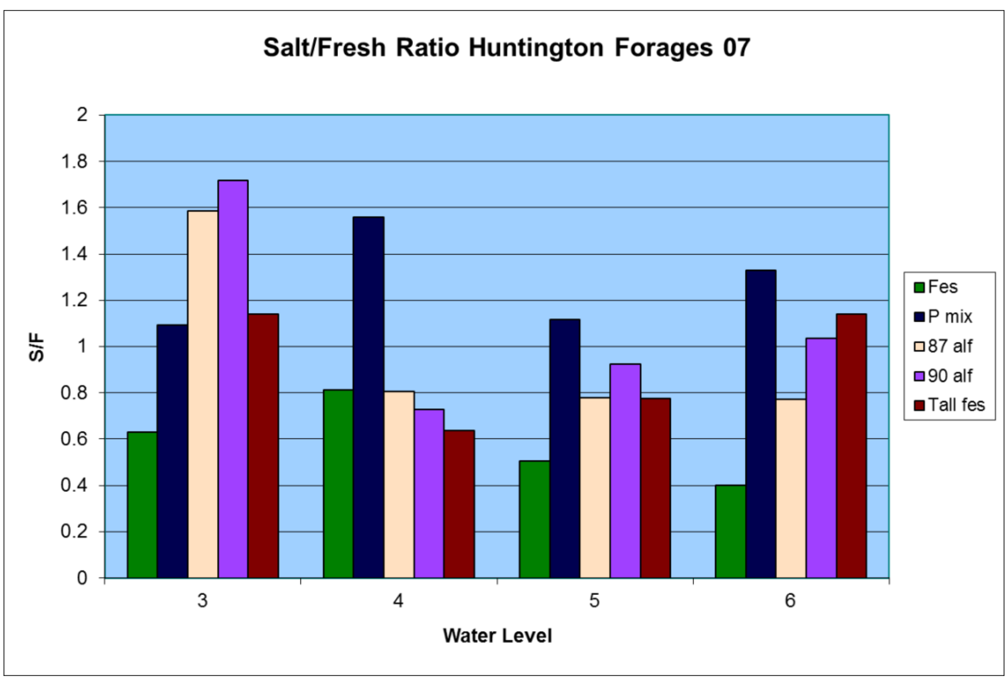
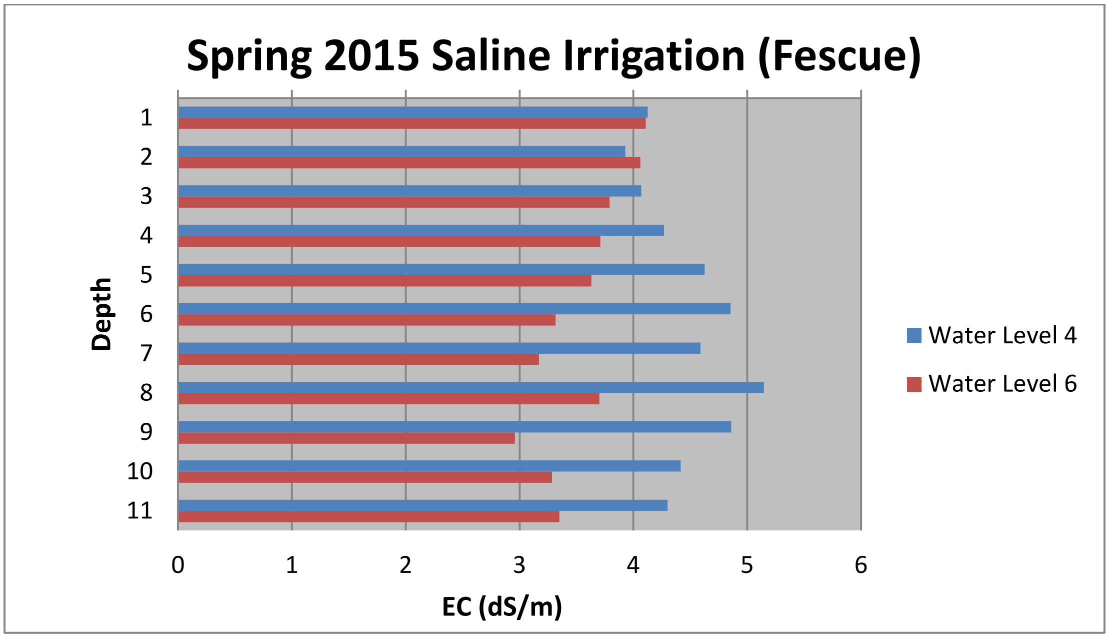


Figure 5. Yield ratio between salty and fresh plots for past fescue, grass mix (P mix) and alfalfa plots at the research farm land application site in 2007

Soil profile distribution of salinity



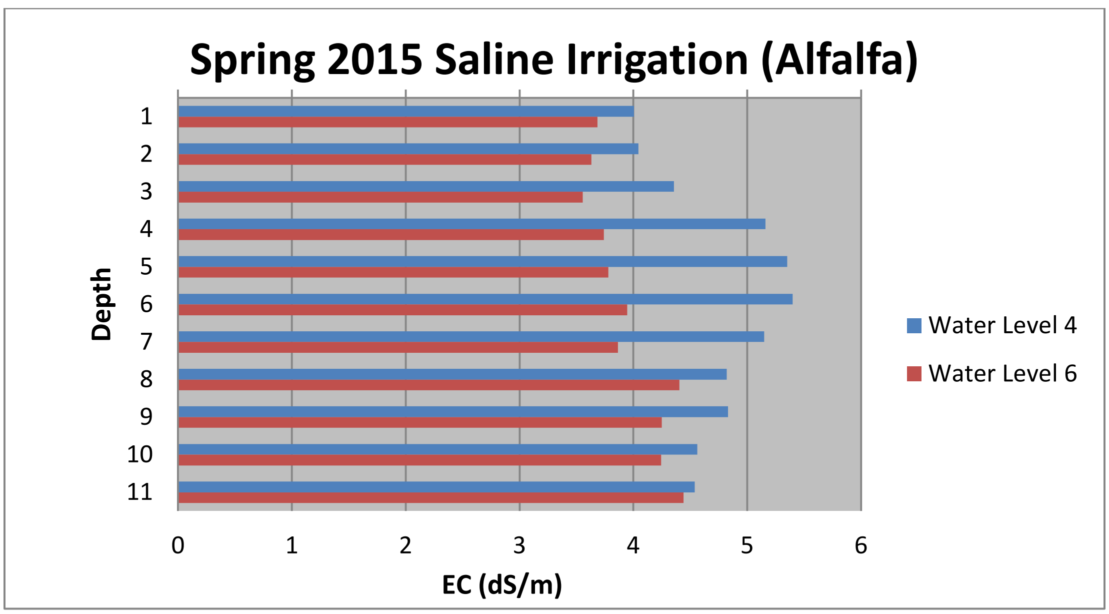
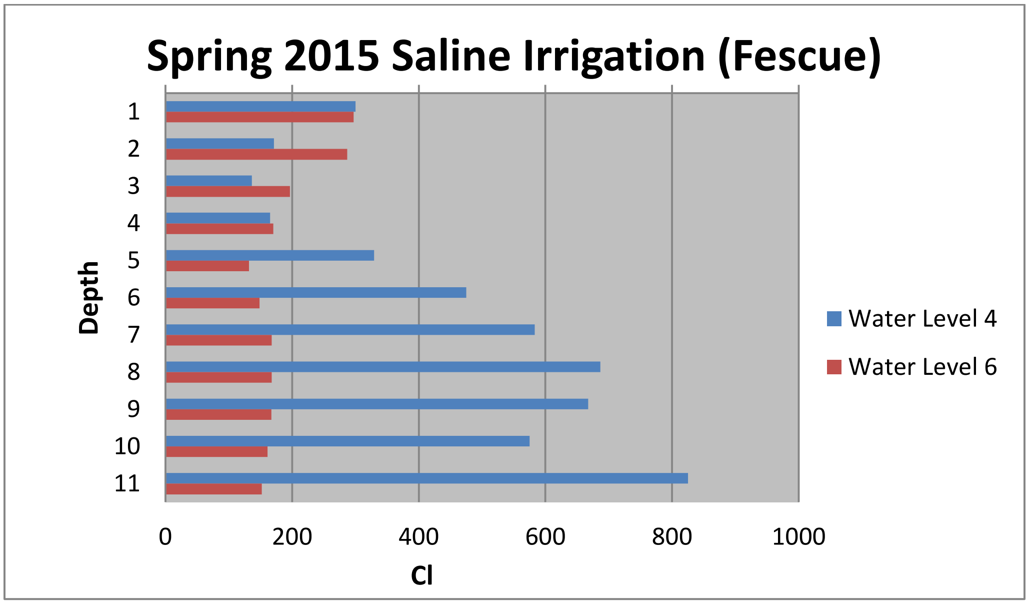


Figure 6. Salinity distribution with depth under fescue and alfalfa in saline water irrigated plots

The salinity distributions for water level 4 in Figure 6 are classic examples of concentration and accumulation of salt due to crop water use in the profile. The saline wastewater management goal is to target the optimal application of saline water that supplies sufficient water for uptake, but allows for storage of salt ions in the soil profile and without leaching. The distribution of salt as indicated by soil Electrical Conductivity (EC, dS/m) for water level 4 shows just that result. Salts are accumulated at higher levels in the soil profile as compared to water level 6, or slightly excess water application.

Individual salt ion distributions, namely Chloride (Cl) and Sodium (Na) are shown in Figures 7 and 8, and are consistent with the overall salinity distribution. The ions Cl and Na are the most soluble and mobile constituents of salinity that we measure, and these show a managed accumulation in the soil profile in water level 4 plots as well (under both fescue and alfalfa).



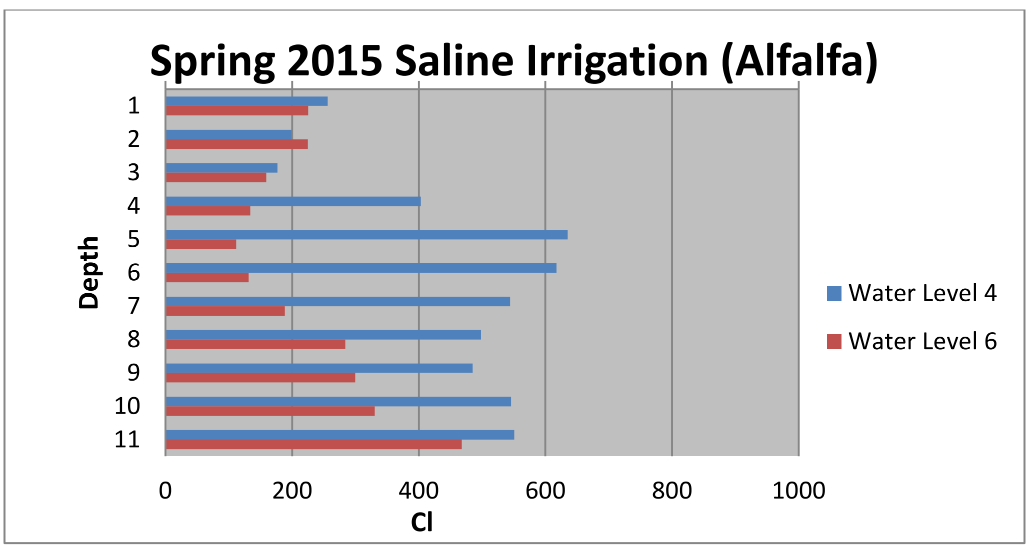
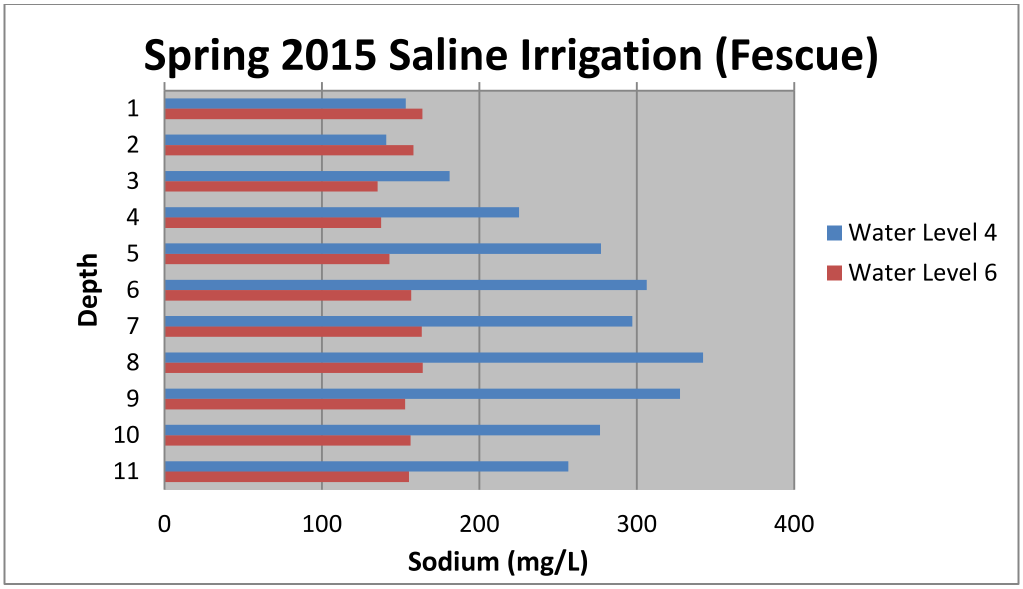


Figure 7. Chloride distribution with depth under fescue and alfalfa in saline water irrigated plots



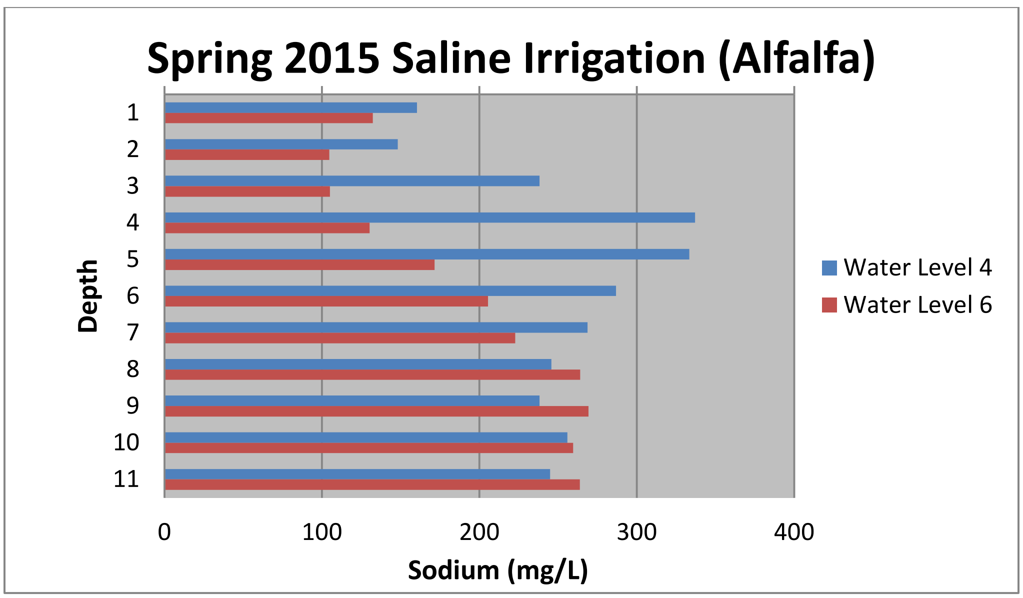


Figure 8. Sodium distribution with depth under fescue and alfalfa in saline water irrigated plots

Water distribution in the soil profile

The following tables show values of average volumetric water content (volume of water per unit volume of soil) in water level 4 plots under both fescue (Table 1) and alfalfa (Table 2) for the saline water irrigated treatments. The reader will note the generally decreasing water content with depth, with the exception of dates later in the season where surface soil drying had occurred. This steady-to-deceasing distribution with depth is additional evidence of continued, productive crop water uptake at the site. No unusual accumulation of water is shown to be occurring in the saline irrigated plots, which meets one of the criteria for continued suitability of the research farm land application site for future applications of saline waste water.

Table 1. Volumetric water content distribution with depth under fescue at noted dates during the 2015 crop season.

Depth (ft)	13-May	4-Jun	25-Aug	15-Oct
1	19.47	20.42	14.42	14.93
2	14.52	19.16	16.11	16.06
3	13.01	18.84	16.40	16.43
4	15.27	19.71	18.54	17.79
5	15.54	19.74	18.20	17.44
6	15.05	19.23	17.51	16.59
7	14.24	19.62	17.13	15.98
8	16.22	19.50	18.57	17.54
9	17.59	18.90	18.98	18.04
10	16.05	16.83	19.18	17.00

Table 2. Volumetric water content distribution with depth under alfalfa at noted dates during the 2015 crop season.

Depth (ft)	13-May	4-Jun	25-Aug	15-Oct
1	19.32	19.76	13.76	13.89
2	11.51	15.45	12.13	11.77
3	11.65	18.99	15.17	13.78
4	14.88	19.04	17.72	16.10
5	14.59	18.15	17.27	14.78
6	14.84	17.69	17.34	15.29
7	12.87	16.48	16.55	14.51
8	13.59	14.71	16.96	15.51
9	11.56	12.60	15.96	15.10
10	11.28	12.05	15.69	14.40

Summary

The evidence, both qualitative and quantitative at the research farm application site, clearly point to continued suitability of the site for future application of saline waste water. The forage crops continue to thrive and yield within acceptable range of paired fresh water irrigated plots at the site; salinity and water distributions are indicative of crop water uptake, and illustrate the success of the managed accumulation approach originally designed for waste water management across all cropped sites receiving saline waste water irrigation.

The designed and applied water management scenario at the Huntington Research Farm land application site will continue to allow for saline wastewater application going forward. This application plan allows for salts to be accumulated and stored in the soil profile above the static level of ground water, while supplying sufficient water in the upper, most active portion of the root zone for productive crop uptake and growth. Wastewater application and management according to this plan will have continued desirable outcomes well into the future.

Appendix H

Confirmation of CCR Removal Efforts for the Huntington Power Plant Historic Scrubber Pond

Description of Historic Scrubber Pond

The scrubber pond (pond) at the Huntington Plant was a 7 acre foot storage pond historically used to store scrubber wastes. The pond covered 28,000 square feet in area and was located north of the coal blend pile and southeast of the Unit One and Unit Two cooling towers. The pond was approximately 6 feet deep at its deepest location. The pond was constructed with an asphaltic bottom and sides with the addition of a poly liner. The thickness of the asphalt was 6” – 8”. Located at the fringe of the poly liner were large, 3’ to 5’ boulders. There were two concrete control structures located in the pond. The inlet structure was a 4’ x 4’ x 3’ high concrete box structure with a 6” HDPE pipe used to historically deliver scrubber waste to the pond. The pond also had a 3.5’ x 5’ x 2’ high concrete structure with an 18” PVC pipe used as an outlet for overflow conditions.

Prior to closure the pond had not been actively used to collect or store scrubber wastes for at least 6 years. At the time of closure, the pond contained approximately 2.5 acre feet of scrubber wastes consisting of FGD wastes, fly ash, bottom ash, coal dust and some soil from rainwater runoff events. The waste was moist from storm water capture and in the lower reaches of the pond was wet (see attached photo).

2015 Cleaning, CCR Removal and Analysis

Clean closing activities on the scrubber pond were conducted during the first week of October, 2015. The activities included the removal of all of the CCR materials with the use of an excavator and dump trucks. The CCR materials were placed in the CCR landfill for final disposal. Over-excavation to native and sandy soils was witnessed by Russ Willson during the CCR material removal portion of the project. Representative soil sampling was conducted on the native materials remaining in the bottom of the pond. The samples were tested for pH, TCLP metals and total petroleum hydro-carbons. The results of the analysis are attached to this document. The concrete structures were demolished and removed to the industrial waste landfill. The asphaltic and poly liners were also removed and disposed of in the industrial waste landfill. After the removal of the CCR materials, liners, structures and boulders was complete, the clean banks of the pond were pulled in and used to fill the void of the pond. Also, in December of 2015, the entire pond closure site was hydro-seeded with a reclamation seed mix to reduce the potential for erosion at the disturbed site (see attached photo)

In view of the historical use of the Scrubber Pond, the understanding that the pond was lined with a combination of asphalt and poly materials, visual and analytical evaluations of the native soil during decommissioning, filling in the pond void with clean materials and the final reclamation of the area, it is our belief that the Scrubber Pond has been properly clean closed.

Scrubber Pond Prior to Decommissioning

Photo Showing the Depth of CCR Materials to be Removed. Photo Also Reveals the Asphaltic Liner Below the Poly Liner.

Scrubber Pond Location after Closure and Reclamation

Analytical Results from Soil Samples

Huntington Power Plant
Closure of Historic Scrubber Pond
September 25, 2015

	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver	pH	TPH-DRO (C10-C28)	VOAs MBTEXN/GRO
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	pH	ppm	ppm
Soil Sample #1	<0.01	0.524	<.0025	<0.01	<.05	<0.01	<0.01	<0.01	8.53	140.0	0.469
Soil Sample #2	<0.01	0.659	<.0025	<0.01	<.05	<0.01	<0.01	<0.01	8.70	38.8	0.0527
Soil Sample #3	<0.01	0.808	<.0025	<0.01	<.05	<0.01	<0.01	<0.01	8.51	59.8	<.0536
Soil Sample #4	<0.01	0.495	<.0025	<0.01	<.05	<0.01	<0.01	<0.01	8.07	34.9	0.0586

Appendix J

Final Closure Plan for the Huntington Research Farm

All Storm water diversion structures and storm water ponds will remain on the farm site to keep storm water from running onto or off of the farm site. Storm water that does not fall on the farm will be diverted around the farm site and into the Huntington River. Storm water that falls onto the farm site will be consumed by the vegetative cover or stored in the storm water ponds.

All fields and bare areas will be over seeded with a mixture of native forbes, shrubs and grasses. The natural precipitation will help to establish the cover of native plant materials. The native plant cover will be sufficient to consume any precipitation that falls on the farm site so as to leave the sequestered salt layer in the soil profile above the static water level of the ground water. There is not sufficient natural precipitation to allow leaching of the salt into the saturated zone.

Ground water sampling will continue on the Research Farm site as outlined in the Huntington Ground Water Discharge Permit #UGW150002.

This addendum is in response to the Utah Division of Water Quality request for more information for the Groundwater Permit Renewal #UGW-150002 concerning the perceived inconsistency in the January 11, 2016 submitted report *Huntington Power Plant Water Quality Analysis*, WET. The apparent inconsistency stems from wording on page 14 which states "The predominant fall timing of the Protection Level exceedances correlates with the highest levels of these constituents in the shallow ground water due to irrigation of the Farm all summer." This statement appears to contradict a statement in the conclusion of the report that states "plant operations have had an inconsequential impact on site water resources."

The difference between these statements is truly one of scale. As shown in Figure 1 of this addendum, the water quality in Huntington Creek is reclassified approximately 5 miles downgradient of the Huntington Plant site from 1C, 2B, 3A, 4 (use classification descriptions are shown below in Table 1 to 2B, 3C, 4. This reclassification indicates that surface water quality is no longer suitable for domestic uses and downgrades from cold water species to nongame aquatic life. This change in water quality is regional as shown by the attached map and occurs in nearby Cottonwood Creek at about the same place topographically. The reclassification is predominantly due to the increases in water quality constituents (sulfate, chloride, TDS, Boron, etc.) from the Mancos Shale. Also note that the name of the bench north and east of the Plant site is "Poison Spring Bench", which is also an indication of the Mancos ground water quality in the area.

Table 1. UDWQ Water of the State Beneficial Use Classification

Classes	Description
Class 1C	Protected for domestic purposes with prior treatment.
Class 2B	Protected for secondary contact recreation such as boating, wading or similar uses.
Class 3A	Protected for cold water species of game fish and other cold water aquatic life.
Class 3C	Protected for nongame fish and other aquatic life.
Class 4	Protected for agricultural uses including irrigation of crops and stock watering.

Ground water moving through the Mancos Shale dissolves highly soluble salts which have a similar chemical signature to infiltration of irrigation water, but the area, concentration and volume are much greater from the Mancos groundwater than from the irrigation water. The Plant has made a concerted effort to operate the Farms in a manner that reduces to the greatest extent possible infiltration of irrigation water. They have worked with Utah State University to design an irrigation system which maximizes evapotranspiration of irrigation water. They monitor three locations on the Farms and have data indicating that each site is maintained so that irrigation water plus precipitation is less than the evapotranspiration (ET) plus net storage of soil water. Stiff Diagrams attached as Figures 2 and 3 indicate the water quality in monitoring wells along a cross section of the Farm from southwest to northeast:

- NH-4W (predominantly Mancos shale ground water),
- NH-5W (mixed alluvial Mancos water),

- NH-6W and NH-8W (predominantly alluvial ground water).

The Stiff Diagrams were created from ground water data collected during the 2nd and 4th quarters of 2013, respectively. Data from 2013 were used because this was a year for which Protection Level exceedances occurred in monitoring wells NH-6W and NH-8W. Figures 2 and 3 illustrate the high major mineral concentrations in NH-4W (Mancos) as compared to the other monitoring wells that are more influenced by surface water.

Water Quality in the creek has been monitored over a long period both up and down gradient of the Plant site. Figures 5, 6 and 7 of the *Huntington Power Plant Water Quality Analysis*, WET, 2016 indicate that water from 1978 to present is very similar. Some constituents at monitoring point UPL-9 (Figure 7) are actually reduced in the later datasets.

NH-8W

Water quality specific to NH-8W was also analyzed in detail. Figure 4 indicates concentration trends over time and Figure 5 illustrates select concentrations in conjunction with ground water elevation. These figures indicate lower more consistent pre-2009 analytical trends which peak in December 2008 to January 2009. An elevated concentration trend continues to present, although the new higher trend is decreasing for TDS, sulfate and chloride.

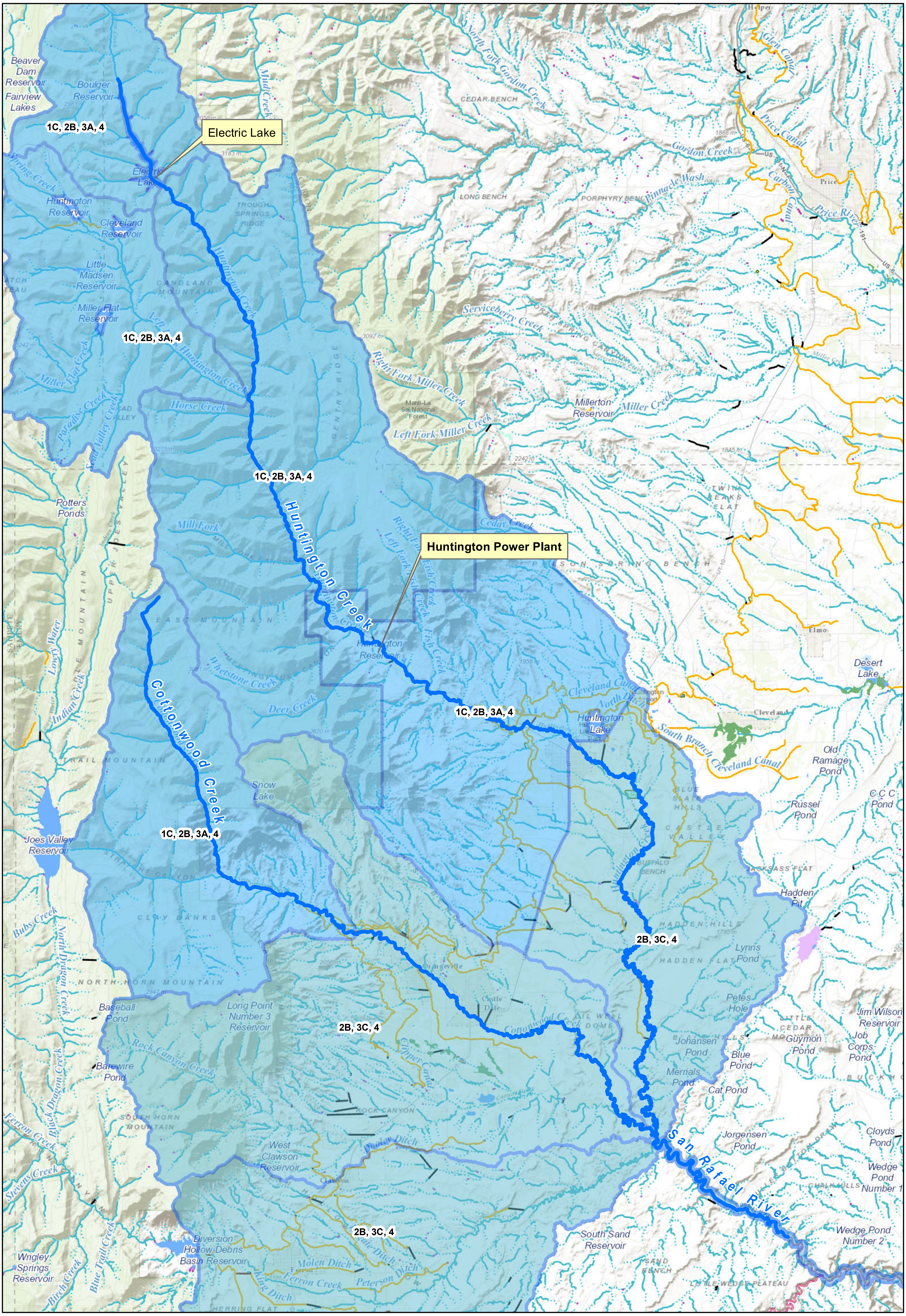
Ground water elevations exhibit an opposite trend with higher elevations pre-2009, a peak in June 2009 and much lower elevations after July of 2012. The lower elevations are coincident with a major scouring event that occurred in the Huntington River just downgradient of the location of this well. This scour decreased ground water elevations locally including those in this well. Although this scouring event and the subsequent reduction in ground water elevation (GWE) reduces the dilution effects of surface water in this well, it is not coincident with the increase in concentrations in NH-8W which occurred prior to this event in the winter of 2008/spring 2009.

The chemical changes in this well are coincident with the installation of drains in the Duck Pond drainage and capture of spring water along the western alluvial valley margin (north of the Duck Pond). This water previously ran along a ditch that discharged into the Huntington River upgradient of NH-8W, providing recharge to both surface and ground water along the way. Chemical analysis of these waters, Table 2 below, indicates the relative quality of these captured waters. Beginning in 2009, these waters were captured and pumped for re-use in the plant. The capture of relatively good quality water (with the exception of the LF Inflow which is a small component of the total captured flow) for re-use appears to be the reason for the water quality changes in NH-8W. Return of these flows should mitigate the effect.

Table 2. 2009-2015 Averages for Flow Components Captured for Re-use at Plant

Sample ID	Calcium (mg/L)	Sodium (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Nitrate (mg/L)	Boron (mg/L)	TDS (mg/L)	Captured Flow (GPM)
LF Inflow	572	2046	2790	4652	12	13	12,100	0.5
DP Inflow	271	322	678	809	1.4	3	2441	40
HG-FD	151	119	207	487	0.7	1	1276	35

In conclusion, although it is generally difficult to differentiate between natural degradation of water quality versus degradation caused by process water infiltration, in this case the magnitude of the effect of the Mancos water greatly outweighs that of the irrigation applied water. This is mainly due to the shear area of Mancos shale available for recharge within the watershed. In addition, the Farm is operated to minimize infiltration of irrigation water. Regional ground water and surface water quality has been impacted by naturally occurring salts and minerals dissolved from the Mancos and localized irrigation water impacts to water resources are negligible compared to these large magnitude effects from the Mancos shale.



Legend

- 1C, 2B, 3A, 4
- 2B, 3A, 4
- 2B, 3C, 4

Miles
0 1.25 2.5 5 7.5 10

Water & Environmental Technologies

Water Classification Map

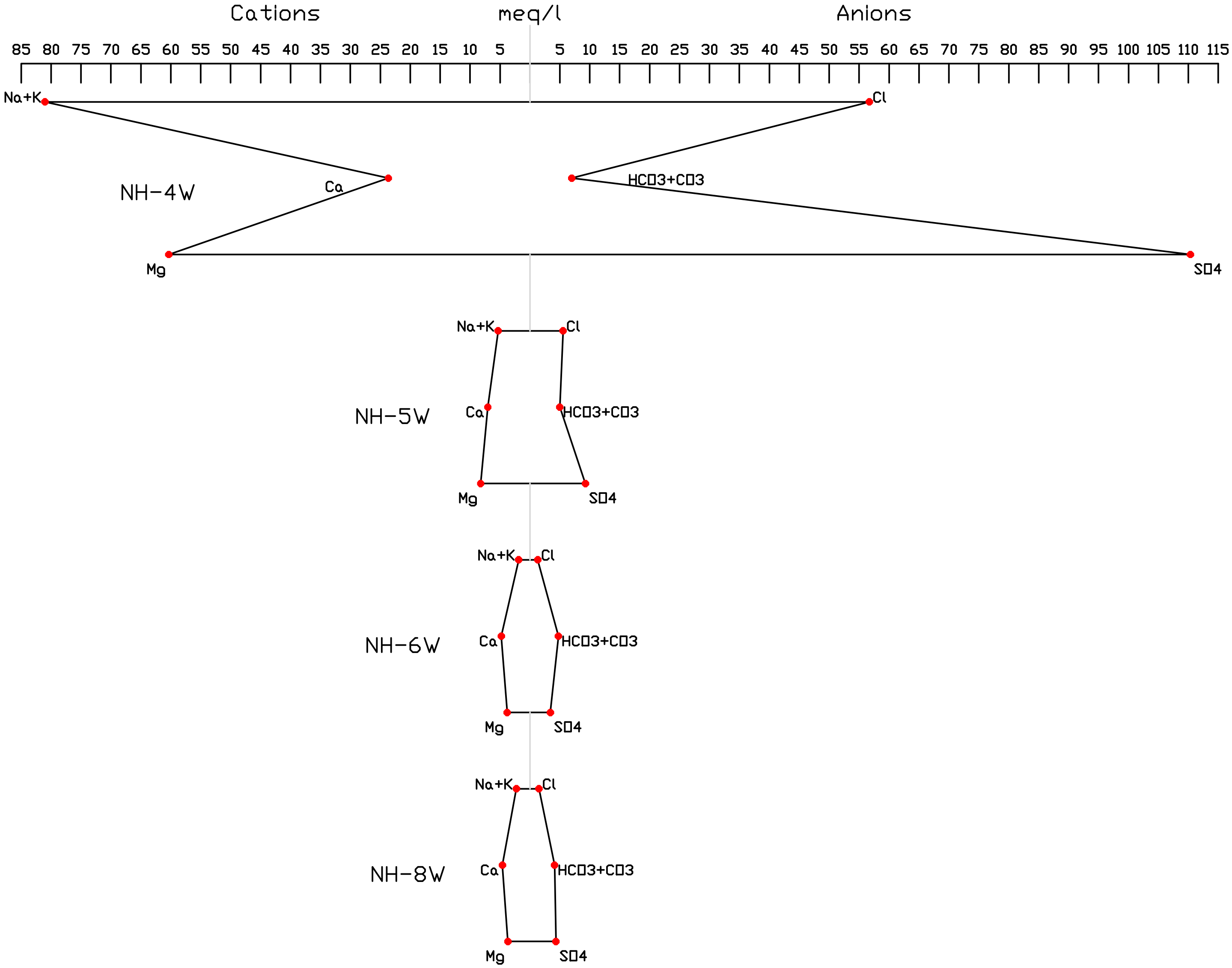
Huntington Power Plant

Job#: PERCM01

Date: 3/14/2016

FIGURE 1

Path: M:\PERCM43\eemap.mxd, Author: jleprowse



Water & Environmental TECHNOLOGIES

PACIFICORP ENERGY

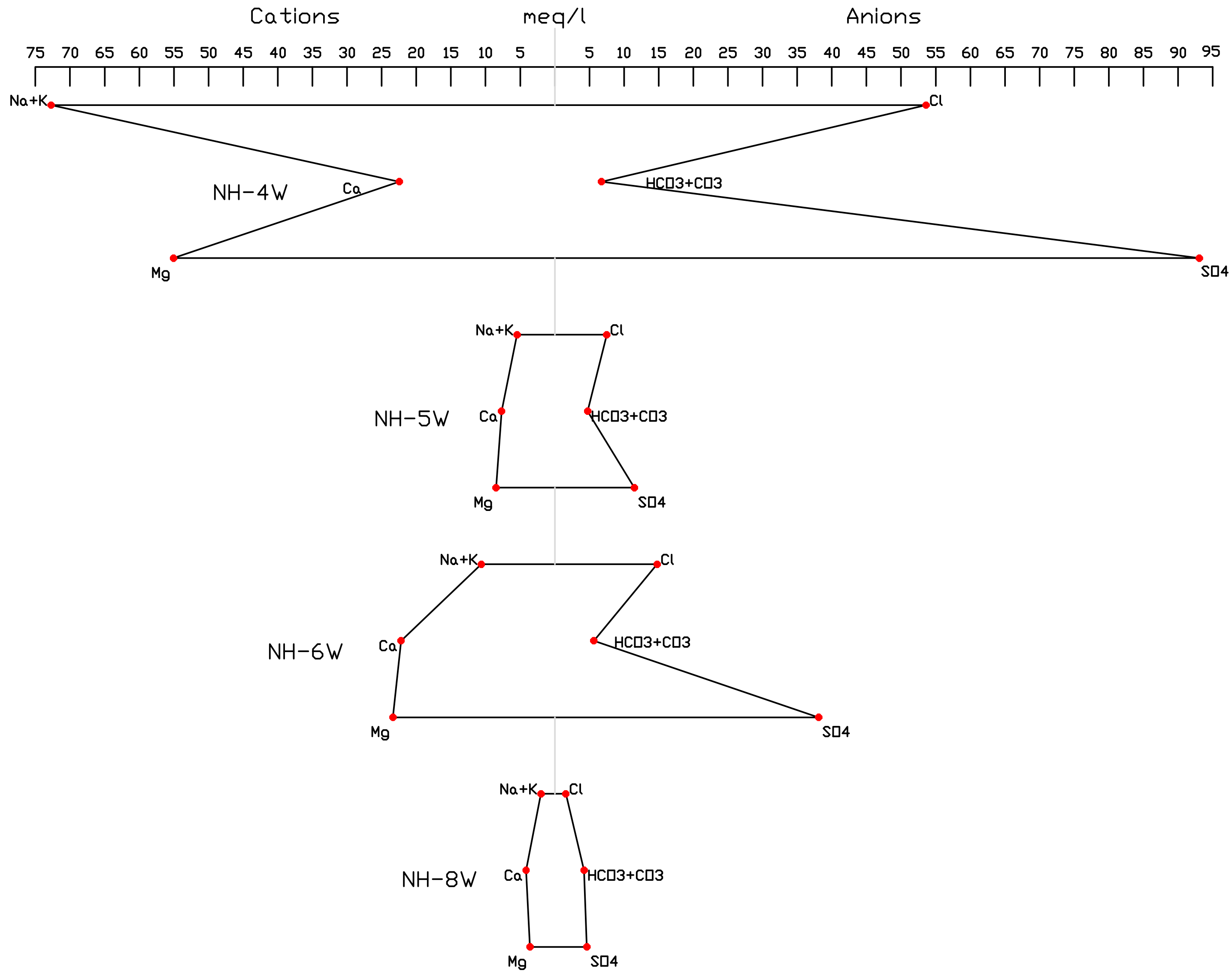
HUNTINGTON

STIFF DIAGRAM FOR 2-13

PERCM43

DATE: 3/17/2016

FIGURE 2



Water & Environmental TECHNOLOGIES

PACIFICORP ENERGY

HUNTINGTON

STIFF DIAGRAM FOR 4-13

PERCM43	**FIGURE 3**
DATE: 3/17/2016	

Figure 4. NH-8W Water Quality Trends

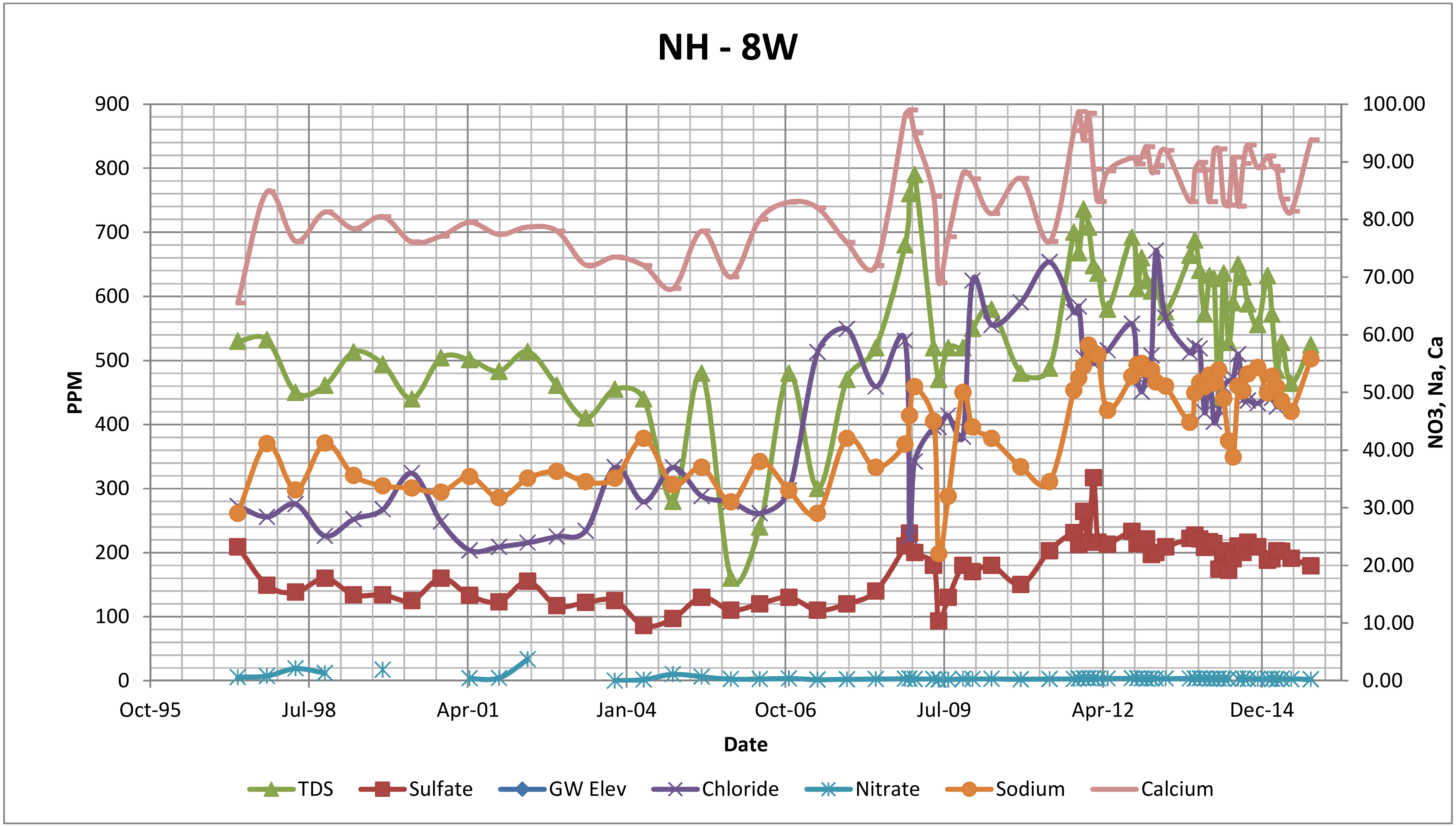


Figure 5. NH-8W Water Quality GWE Trends