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Source Approval Documents City of Longview Mint Farm Wellfield

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Section 1: Introduction and Background

1.1 Introduction and Document Organization

This document provides information necessary for Washington State Department of Health (DOH) approval of four deep aquifer wells as the source of drinking water for the City of Longview, Washington as required in Washington Administrative Code (WAC) 246-290-139. After source approval is obtained, the City of Longview requests the wells be considered a wellfield as defined by WAC 246-29-010 (302).

Section 1 of the document provides general background information regarding the need for the new source of supply and initial planning, engineering, and hydrogeological work that led to the construction of the initial four wells and new treatment facilities. Space has been allocated in the proposed wellfield to construct two additional wells, as needed to meet future growth needs, for a total of six wells at build-out. The new treatment facility has also been designed to accommodate future expansion. Much of the information presented in this section was extracted from the City's *Mint Farm Regional Water Treatment Plant Preliminary Design Report* (Kennedy/Jenks Consultants 2010).

Section 2 of this document provides common information applicable to all of the wells and proposed wellfield. Sections 3 through 6 include information specific to each well (well log, well tag number, water quality results, etc.). The Appendices include copies of various documents for easy reference.

1.2 Background

1.2.1 Regional Water Treatment Plant Nearing End of Useful Life

The City of Longview and the Beacon Hill Water and Sewer District (BHWSD) own the existing Regional Water Treatment Plant (RWTP) on the Cowlitz River which provides potable water to customers in their respective service areas. The City is the majority owner and operates the RWTP. Throughout this report, use of the term "City" generally means the combined efforts of the City of Longview and BHSD, although the City of Longview is managing the project and contracting with consultants.

The RWTP performance, capacity, and service life was evaluated and documented in the 2005 Water System Plan prepared for the City of Longview and the Cowlitz County Public Utility District No. 1 (Cowlitz PUD), predecessor of BHWSD (Kennedy/Jenks Consultants 2005). This study showed that major equipment and facilities at the RWTP have reached the end of their service life, and that the RWTP intake has become increasingly unreliable due to continuing silt and debris accumulation. In addition, the intake does not meet fish screening requirements. As a consequence, the City's potable water supply is not consistently reliable. The City is currently constructing facilities necessary to re-establish a reliable source of potable water supply to provide a maximum day demand capacity of at least 17.4 million gallons per day (mgd) to customers in their respective service areas.

1.2.2 Examining Groundwater as a New Source of Water Supply

For more than 30 years, the RWTP has experienced significant impact from sediments in the Cowlitz River due to the 1980 eruption of Mt. St. Helens. Given the increasing and precarious nature of sediment movement and deposition in the Cowlitz River, efforts to reduce or control sediment accumulation at the RWTP intake and upgrade fish screening will require extensive and expensive repairs and replacement of facilities, and may ultimately be unsuccessful. That risk, along with the aged and deteriorated condition of the RWTP, prompted the City to consider alternative sources of water supply.

The option of building a new groundwater facility at the Mint Farm Industrial Park was identified previously as a way to provide the City with a long-term, reliable water supply, less expensively and more quickly than rehabilitating the RWTP and Cowlitz River intake. To begin evaluating the potential of groundwater as a new source of water, the City commissioned a number of studies examining groundwater at the Mint Farm Industrial Park. Studies prepared included the following, along with various peer reviews and a value engineering review conducted by independent engineering firms:

- *Source Analysis, City of Longview,* PACE Engineers Inc., 27 October 2006 – A source of supply and feasibility study for a Mint Farm groundwater supply.
- *Proposed Mint Farm Wellfield Area Environmental Review,* GSI Water Solutions, Inc., 5 May 2008 – An assessment of potential contaminant sites in and around the Mint Farm.
- *Pilot Study for Potential Microfiltration Plant on Groundwater,* PACE Engineers Inc., 11 July 2006 – A brief pilot study of deep aquifer groundwater treatability.

The studies concluded the groundwater in the deep aquifer at the Mint Farm would be a suitable source for the City's municipal water supply.

1.3 Preliminary Design Report on Mint Farm Groundwater Option

In March 2009, the City retained Kennedy/Jenks Consultants to perform more extensive studies of the Mint Farm groundwater option. The initial objective of Kennedy/Jenks' efforts was to assess the assumptions and conclusions developed in previous work through a comprehensive site investigation and prepare a Preliminary Design Report (PDR) detailing the findings of the investigation. The PDR work included an investigation of the environmental condition of the Mint Farm site, conducted a rigorous and thorough water quality investigation upon which a Human Health Risk Assessment (HHRA) of the Mint Farm aquifer was based, conducted field investigation and documentation of the deep groundwater aquifer hydrogeologic characteristics, and prepared an initial Wellhead Protection Plan that incorporated the water quality and hydrogeologic findings. This work was documented in the draft comprehensive PDR report, dated March 2010. After DOH comments on the report were addressed, the plan was approved by DOH on 12 August 2010.

The PDR was divided into three parts:

- Part 1, Basis of the Design - Addressed the fundamental treatability of the Mint Farm deep aquifer, presented treatability pilot study results, provided an engineering and cost analysis to select the best treatment alternative, and provided preliminary design information.
- Part 2, Hydrogeology and Water Quality Considerations - Presented results from the broad hydrogeologic investigation and health risk and water quality assessment. Began outlining the required management tools to protect the new groundwater supply.
- Part 3, Environmental Permitting and Archaeological Investigations - Presented the environmental permitting process and archeological assessments necessary to gain state and federal approval for the project.

1.3.1 PDR Part 1 – Basis of Design Report

In Part 1, fundamental water treatment engineering criteria were used to examine previously proposed treatment alternatives, develop and investigate new treatment alternatives, and provide preliminary design and cost information.

The work of Part 1 included reviewing and validating previous project reports; field-piloting proposed alternatives where there was inadequate field treatment data; developing an alternatives evaluation procedure and ranking the proposed treatment processes; and preparing a planning-level cost estimate for the recommended treatment process as part of a preliminary design package.

Part 1 also included examining alternative pipeline routes by which the new treatment plant would be connected to the existing distribution system.

1.3.1.1 Water Treatment Conclusions

- ***Iron and manganese found to be the only elements that require treatment.*** Sampling and analysis of groundwater in the deep aquifer below the Mint Farm indicated that the only constituents requiring treatment are iron and manganese. Iron and manganese are not a human health concern, but they may cause unpleasant taste or odors and may result in staining of clothes and fixtures if left untreated.
- ***Arsenic present but below safe drinking-water limits.*** Arsenic detected at the final selected Mint Farm wellfield site is below state and federal drinking-water limits but in some cases may be above the 5.0 micrograms per liter (μg/L) public notification requirement. Work conducted during the pilot plant analyses demonstrated that Arsenic concentrations in the finished water will be reduced well below the 5.0 μg/L reporting level.
- ***Filtration including oxidation is recommended*** to remove iron and manganese.
- ***Greensand granular media is the preferred groundwater treatment method.*** A pilot study tested the performance of several different forms of granular media for treating

groundwater at the Mint Farm. The pilot study showed that greensand granular media met the treated water goals for iron and manganese removal and is the preferred treatment for this groundwater. Arsenic, though present at the site below safe drinking-water levels, was also found to be readily and effectively removed by the greensand filtration process. Other treatment process findings include:

- A filter flow rate of about 5.5 gallons per minute per square foot (gpm/ft^2) was established as an appropriate rate of treatment, well in line with industry standards for this process.
- Facilities design should allow for a filter-to-waste period following a filter backwash to mitigate iron and manganese concentration in the filter effluent. Additionally, the facilities design should include backwash water settling and recovery to increase the efficiency of use of the groundwater supply.
- At start-up of a new regional water treatment plant, water characteristics and changing flow directions in the distribution system may cause transitional issues during the shift from the City's surface-water source to the groundwater source. The City has performed a flushing program to mitigate sloughing within the distribution system pipes, and has prepared a public outreach program to address possible complaints about temporary color, odor, and taste issues, and increased hardness of the groundwater. A commissioning and start-up plan is being prepared in accordance with the requirements of the design specifications.

- ***Cost analysis comparing greensand filtration of Mint Farm groundwater with rehabilitation of existing plant identified the Mint Farm option as the most cost-effective method.*** After Part 1 work concluded that greensand filtration would provide excellent water quality, and Part 2 work concluded the Mint Farm aquifer would provide a near-endless supply of high quality water, cost analyses determined the Mint Farm option has lower initial capital cost and lower long-term operational costs compared to the option of rehabilitating the existing RWTP.

1.3.1.2 Evaluation of Treatment Alternatives

Once pilot testing demonstrated that filtration including oxidation should be used to treat the deep aquifer groundwater, the City needed to further analyze feasible filtration technologies – including those considered previously – and confirm the best one to use.

- ***Five phases of evaluation.*** Filtration alternatives were evaluated in five phases: 1) identification and briefing of project stakeholders; 2) discussion and selection of filtration alternatives; 3) discussion and selection of evaluation criteria; 4) preliminary work for stakeholder preparation to evaluate; and 5) final workshop evaluation and selection.

- ***Two filtration alternatives targeted.*** Because of the previous project work and the body of knowledge on water filtration treatment, two feasible filtration technologies were selected for evaluation: granular media filtration and membrane filtration. The pilot test described above indicated that the granular filtration technology to be evaluated should be greensand granular media filtration.

- ***Evaluation criteria encompassed stakeholders' primary concerns.*** The criteria for evaluation were established and weighted on the basis of stakeholder concerns. They included capital cost, net present value, operability, performance, flexibility, complexity, capacity, and regulatory acceptance. The alternatives were compared using these criteria and evaluation matrices.

- ***Greensand filtration scored highest of filtration methods.*** The alternatives evaluation established that greensand filtration is the preferred process for treating Mint Farm groundwater. Membrane filtration was found to be less efficient and more costly, and it scored lower.

- ***Cost analysis comparing filtration alternatives with existing plant rehabilitation also identified greensand filtration as most cost-effective method.*** Because cost was significant to the City in all decisions made about this project, the costs of the two targeted filtration methods and the cost of rehabilitating the existing treatment plant were compared. (This comparison provided cost perspective even though existing plant rehabilitation is not considered a viable alternative because of the continued vulnerability of this source water to silt-laden flow that plugs the intake system, consequent higher maintenance costs, risk of flood-induced water quality degradation, and risk of contamination with contaminants of emerging concern.) The results showed that using a groundwater supply at the Mint Farm along with greensand filtration was significantly lower in capital and net present value cost than either rehabilitation of the existing treatment plant or membrane filtration of Mint Farm groundwater.

1.3.1.3 Summary of Features for Mint Farm Regional Water Treatment Plant (MFRWTP)

Site Located on 10 acres of the Mint Farm Industrial Park. The MFRWTP is situated on an approximately 10-acre site in the south-central portion of the Mint Farm Industrial Park in Longview, Washington. A vicinity map of the site is shown on Figure 1, and a site plan is shown on Figure 2. The site has been developed in accordance with the Mint Farm covenants and other applicable regulations. Among other things, these regulations stipulate several features of the work – building setbacks from property lines, building facades and exterior features, landscaping, requirements for site access and roads, and provisions for a stormwater storage and treatment bioswale.

Greater than sufficient quantity, plus good quality. Test wells in the area indicate not only that groundwater quality can easily be treated to potable standards, as discussed above, but also that the volume of water available from the aquifer is more than sufficient to meet maximum day water demands within the MFRWTP service areas beyond a 50-year planning period (2059).

The new MFRWTP may ultimately have as many as six groundwater production wells, although only four well pumps are currently in place and equipped with pumping facilities. Construction activity within the wellhead sanitary protection zone (100-foot radius around each groundwater well) was minimized and the work completed in accordance with the City's wellhead protection program.

Treatment process information. As noted above, iron and manganese were found in the deep aquifer and will require treatment, with the goal to reduce concentrations well below the secondary maximum contaminant levels (SMCLs). The treated levels of iron and manganese are anticipated to be acceptable to consumers because they will prevent the staining these metals can cause. The City also wants to maintain arsenic levels below the DOH trigger (5 µg/L), which requires mandatory reporting language concerning the level of arsenic in the finished water to be included in the City's Consumer Confidence Report (CCR). The treatment process design includes eight greensand filters, six which are being installed initially.

The water will be chlorinated before being filtered. A hypochlorite disinfectant solution will be delivered in bulk and stored onsite for a maximum of about 30 days to minimize the amount of chemical degradation over time. A chlorine residual will be carried though the filtration process. A minimum contact time (CT) of 6 mg/L-minutes will be provided prior to entering the distribution system with the residual continuously monitored and recorded by the supervisory control and data acquisition (SCADA) system. High and low level alarms will also be provided.

Fluorosilicic acid will be added to the filtered water to increase the fluoride level to a desired level of 0.8 milligram per liter (mg/L). Sodium hydroxide will also be added to adjust the pH from 7.2 or 7.3 to a target of 7.6 in order to match the pH produced by the existing surface water treatment plant to minimize impacts to the distribution system and the regional sewer treatment plant.

Filter backwash will be held in concrete basins to allow solids to settle out. The settleable solids will be transferred to Geotubes™, a woven geotextile that has been stitched together in the shape of a large bag. The fabric will allow filtered water to drain from the Geotube™, and solids will remain inside the bag. Once the bag has reached its solids storage capacity, the bag will be cut open and the inert solids and used bag removed with a front-end loader and hauled to a landfill.

The treatment facility also includes a standby generator, a new transformer, and all other mechanical, electrical, and instrumentation required to make a complete and operable facility.

Structures located onsite. Several new structures are located on the new treatment plant, including four well houses for the groundwater pumps, a filter gallery building containing the face piping of the greensand filters, equipment building containing air scour blowers, two backwash storage tanks for backwash water recovery, maintenance building, office/treatment building for operations activities and chemical storage, and sludge drying beds for the Geotubes™. For some of the larger structures, pre-loading of the site was required to consolidate soils underneath the buildings.

New transmission main. Approximately 6,000 lineal feet of new 30-inch ductile iron transmission main connects the MFRWTP to the existing distribution system and reservoirs. The 30-inch force main alignment generally heads east from the MFRWTP, then north along the western side of the mitigated wetlands connecting to the existing 20-inch-diameter main on the southern side of Consolidated Diking Improvement District (CDID) drainage ditch. A12-inch spur from the 30-inch water main connects with a 12-inch water main in the vicinity of Hemlock Street near the railroad tracks, and second 12-inch connection was made to the 12-inch water main in Weber Avenue. The transmission main traverses mostly undeveloped areas with few utility crossings.

1.3.2 Hydrogeology and Water Quality Considerations

Concurrent with the water treatment investigation and piloting, a major effort of the PDR was to document the characteristics and suitability of the Mint Farm deep aquifer to serve as a raw drinking water source in perpetuity for the City to replace the existing Cowlitz River raw water source. PDR Part 2 evaluated water quality of the shallow and deep groundwater at the Mint Farm, and evaluated the relative water quality of the Mint Farm groundwater compared to surface water from the Cowlitz River and the Columbia River.

The hydrogeological characterization and water quality assessment of the Mint Farm deep aquifer were based on a field program that consisted of the installation of a network of 17 paired shallow and deep monitoring wells in the Mint Farm area, the installation of a test production well (PW-1), and collection of potential raw source water samples. Groundwater and soil samples and field measurements were collected and, as of January 2010, more than 16,300 tests had been performed to facilitate hydrogeologic characterization and water quality assessment of the Mint Farm aquifer. Appendix A is Part 2A of the PDR (Hydrogeologic Characterization).

1.3.2.1 Physical Setting

Longview is situated along the northern bank of the Columbia River in southwest Washington and is bounded on the east by the Cowlitz River. The proposed groundwater wellfield is located in the western part of the city in an area known as the Mint Farm Industrial Park as shown on Figure 1, Vicinity Map. The site had been used for agricultural operations, including mint and grass farming, until about 1975. The wellfield is located near industrial and commercial businesses, managed wetlands, and undeveloped property.

The Longview-Kelso Basin (Basin) covers approximately 35 square miles in the vicinity of Longview, Washington, near the confluence of the Cowlitz and Columbia Rivers. The Mint Farm Site is situated in the southwestern portion of the Basin near the confluence of the Columbia and Cowlitz Rivers; refer to Figure 1. General subsurface conditions in the Longview-Kelso Basin consist of a valley eroded into the underlying bedrock subsequently infilled with sediments. Near the surface over a large portion of the Basin is a clay silt deposit that typically thickens to the south toward the Columbia River. This deposit tends to be present in the eastern portion of the basin but varies from thin to absent in areas of the western portion of the basin. The geology beneath the Mint Farm Site and surrounding area consists of thick deposits of silt, clay, sand, and gravel covered by thinner deposits of silty sand, silt, and clay. Where present in the Basin, the clayey silt deposits form an effective confining layer.

1.3.2.2 Field Investigations

From February to July 2009, eight shallow monitoring wells (SW) and nine deep monitoring wells (DW) were installed to facilitate aquifer characterization of the Mint Farm area (Figure 3). The deep monitoring wells range in total depth from 276 to 456 feet below ground surface (bgs) with casings extending from 240 to 370 feet bgs. Most of the deep borings were drilled to the bottom of the coarse/gravel alluvial deposit/top of bedrock contact. The shallow monitoring wells were completed in a thick sequence of generally silty sediments at depths ranging from 30 to 50 feet bgs.

Based on the information gathered from installation of the monitoring wells, a test 24-inch-diameter production well (PW-1) was constructed into the deep aquifer. After completion, this well was pumped continuously for 36 days and water quality samples were tested before, during, and after this long-duration pump test.

The field program consisted of the installation, field measurements, and water quality testing of the monitoring and test wells, including the following:

- Geochemical sampling of groundwater and soil from the monitoring wells to support aquifer characterization and water quality evaluation for the Environmental Risk Assessment.
- Transducers were installed in all monitoring wells to record fluctuations in groundwater elevation for aquifer characterization. In addition, transducers were installed in production well PW-1 and two private domestic water wells at residences on Mt. Solo.
- The monitoring wells and nearby private wells were sampled to characterize groundwater quality in the Mint Farm area. Surface water samples were collected from the Columbia and Cowlitz Rivers.
- A long-term aquifer test was conducted at test production well PW-1 to evaluate aquifer conditions. PW-1 was pumped at 3,900 gallons per minute (gpm) for 36 days.
- Three additional production wells (PW-2, PW-3, and PW-4) were constructed in 2011 and pump tested for 12 hours each.

The hydrogeological characterization was based on the data collected during the field program. A summary of the aquifer evaluation is provided below.

1.3.2.3 Groundwater Aquifer

Two distinct ground groundwater systems are present at the wellfield site, a shallow system and a deep aquifer system. Three general geologic units underlie the Mint Farm area: (1) a low-permeability zone consisting of silt, silty sand, clay with interbedded fine-grained sand, (2) a fine- to medium-grained sand unit, and (3) an unconsolidated coarse-grained deposit of gravel and cobbles with minor occurrences of sand. Figure 4 shows a soil cross section at DW-9 and Figure 5 illustrates the various aquifers and gravel aquifer flow paths.

1.3.2.3.1 Shallow Groundwater System

The shallow groundwater system consists primarily of fine-grained silt and clays with silty sand interbeds. This unit that overlies much of the basin area is a thick silt/clay unit that, where present, acts as a confining layer to the underlying sand and gravel aquifers. Where absent, the sand and gravel aquifers are considered to behave as unconfined systems.

The upper fine-grained materials consist of silt with varying percentages of clay and fine sand. The upper silt/clay sequence is thickest in the southern part of the Mint Farm area, nearer to the Columbia River, where it ranges from 100 to 200 feet thick; this layer thins appreciably to the north and east. At both the SW-4/DW-4 and SW-3/DW-3 monitoring well locations, the clay silt deposits are only about 15 feet thick and are underlain by the fine- to medium-grained sand of the sand unit discussed below.

1.3.2.3.2 Deep Groundwater System

The deep groundwater system forms the primary water-bearing zones and can be further subdivided into a sand aquifer and a gravel aquifer that have distinct hydrogeologic characteristics.

The sand aquifer consists of fine- to medium-grained sand with minor amounts of very fine sand and silt, and is prevalent across the northern portion of the Mint Farm area. The sand aquifer ranges in thickness from approximately 30 feet in monitoring wells located to the south along Industrial Way to approximately 250 feet in monitoring wells DW-3 and DW-4 located to the north and east. The sand aquifer is found primarily in the areas where the gravel is absent; however, a thin extension of the sand does overlie the gravel layer in several areas.

The gravel aquifer is present in the southwestern part of the Longview-Kelso Basin. In deep monitoring wells installed just south of the Mint Farm area along Industrial Way, the gravel unit ranges from about 100 to 150 feet in thickness. In the area of monitoring well DW-4 at the northern edge of the Site, a 1- to 2-foot thickness of gravel is encountered just above bedrock. At the DW-3 monitoring well location east of the site, the gravel unit is approximately 50 feet thick.

1.3.2.4 Hydrogeological Conceptual Model

The hydrogeological conceptual model summarizes the key hydrogeological data from the Longview-Kelso Basin and is an interpretation of how groundwater flows through the Basin. This narrative discussion is based upon the hydrogeologic data collected and compiled for this project, and from previous investigations.

The primary groundwater recharge sources for the Basin are precipitation and infiltration from the Cowlitz and Columbia rivers. The primary groundwater outflows from the Basin are discharges to the CDID drainage network. Much of the Basin is only slightly higher than the elevations of the Columbia and Cowlitz Rivers. CDID maintains 35 miles of stormwater collection ditches that have been constructed across the Basin for flood protection. The system consists of six primary pumping stations with a total capacity of 628,000 gpm that discharge to the Columbia and Cowlitz Rivers. Active pumping of these ditches has resulted in lowering of the shallow groundwater levels. Water levels in the drainage ditches are maintained at levels several feet below the typical stage of the Columbia River with the lowest water levels maintained in the western portions of the Basin.

The interactions of the aquifer heterogeneity and the groundwater-surface water interactions with the rivers and drains cause a complex groundwater flow pattern in the Basin.

The shallow groundwater flow is dominated by the CDID drainage ditches. Geochemical data indicate that the source of groundwater recharge in the shallow deposits is primarily from local precipitation. Groundwater flow is localized with flow through the shallow deposits and discharge to the nearest CDID drainage ditches.

Groundwater flow in the deep sand aquifer is primarily from southeast to northwest across the Basin. Geochemical data indicate that the primary source of groundwater recharge in the sand aquifer is from precipitation and infiltration from the Cowlitz River. Discharge from the sand aquifer is predominantly to the CDID drainage ditches in the western portion of the Basin where the confining layer is thin to absent.

Groundwater flow in the gravel aquifer is from west to east. Geochemical data indicate that the primary source of groundwater recharge for the gravel aquifer is the Columbia River. Geologic data indicate that the confining layer varies from thin to absent in the western portion of the Basin. A portion of the gravel aquifer underneath the Columbia River is not overlain by the confining layer, thus allowing direct contact between the gravel aquifer and the Columbia River. Groundwater from the river is interpreted to flow into and through the gravel aquifer and discharge to the sand aquifer along the areas where the sand and gravel aquifers are in direct contact. Flow from the sand aquifer then discharges to the CDID ditches, where it is pumped back into the river.

1.3.2.5 Wellfield Impact Analysis

A three-dimensional numerical groundwater model was developed and calibrated using the United States Geological Survey (USGS) code MODFLOW 2000 (Harbaugh et al. 2000). The purpose of the numerical model was to test the hydrogeological conceptual model that was developed for this study and to evaluate the impacts of long-term groundwater production at the proposed Mint Farm Wellfield. Data in the model included geologic factors that control groundwater flow, key physical features of the study area, surface water-groundwater interactions (e.g., the Columbia River), hydrologic water balance components (e.g., precipitation and flow to drainage canals), and the distribution of aquifer properties (e.g., aquifer thickness and hydraulic conductivity). The assumptions and inputs used in the MODFLOW model, and the model results, were reviewed and concurred with by Pacific Groundwater Group as part of the Washington State Department of Ecology (Ecology) technical review for issuance of the City's new groundwater right.

Model calibration is the process of comparing model results to measured data to test the model's ability to simulate observed conditions. During model calibration, aquifer properties and boundary conditions are varied within an acceptable range until the closest fit is achieved between the simulated and measured data. The amount and type of data that are available in large part dictate the model calibration steps. The model was calibrated against two independent data sets:

- The base-case MODFLOW model was calibrated using river stages, river gradients, and monitoring well groundwater elevations for the period 12 September 2009 through 24 September 2009. The base-case model was found to be in good agreement with the observed data.

- A pumping-case model was also calibrated against data from the PW-1 long-term aquifer pumping test. The MODFLOW Model was found to reasonably match the aquifer response observed during the pumping test.

- In the conceptual model, groundwater flow in the Longview-Kelso Basin is dominated by the Columbia River and the CDID drainage ditches. This conceptual model was tested by the MODFLOW Model. Using an acceptable range of aquifer parameters and boundary conditions, the conceptual model was found to be a valid representation of groundwater flow in the Longview-Kelso Basin.

Once calibrated, the MODFLOW model was used to evaluate the sustainability of long-term pumping from the deep gravel aquifer for the Mint Farm Wellfield at full build-out. The total simulated production was 12 mgd, divided equally among six production wells spaced 200 feet apart (four existing wells and two future wells). This pumping rate represents the average day demand (ADD) at full build-out; maximum day demand was not used because it is a scenario that occurs with limited frequency during the year and is a short duration event lasting only several days in length. Also included was an additional 4.1 mgd of pumping at the neighboring properties of Puget Sound Energy and Millennium Bulk Terminals (formally Chinook Ventures and Reynolds Aluminum). Drawdown at the wellfield was calculated to be approximately 6 feet at full build-out. That drawdown is a very small amount compared to the volume of water being withdrawn, and is limited within close proximity to each well.

The groundwater modeling confirms the Mint Farm Wellfield is capable of sustaining the planned pumping rates, and that water from the Columbia River recharges the deep gravel aquifer.

1.3.2.5.1 Delineation of Source Areas / Time of Travel

The model was also used to delineate the aquifer source areas for use in developing the Wellhead Protection Plan (WHPP) and evaluating potential impacts to groundwater quality. The particle-tracking program MODPATH (Pollock 1994) was used to delineate the Mint Farm wellfield source areas. MODPATH calculates groundwater flow paths based on the hydraulic gradient calculated by the MODFLOW simulation.

The MODFLOW model estimated that over 99 percent of the water pumped at the Mint Farm wellfield was ultimately derived from the Columbia River. Source water enters the aquifer at locations where the Columbia River channel intersects the gravel unit west of the Mint Farm site (Figure 6). The MODPATH analysis indicates that travel times for water from the Columbia River source areas to reach the Mint Farm Wellfield ranges from approximately 2 years to over 10 years at the ADD of 12 mgd plus 4.1 mgd for neighboring gravel aquifer wells. This travel of time through the gravel aquifer provides the natural filtration that maintains the high quality of water in the aquifer.

The assumptions and inputs used in the MODPATH program, and the results of the MODPATH analysis, were reviewed and concurred with by Pacific Groundwater Group as part of Ecology's technical review for issuance of the City's new groundwater right.

1.3.2.5.2 Pathway Analysis for Potential Future Contamination

The gravel aquifer production wells do not meet the definitions of potential groundwater under the direct influence of surface water (GWI) as defined by DOH in Policy Number F.12., because they are located more than 200 feet from a surface water, and have their first screened interval more than 50 feet from ground surface at the wellhead.

A screening-level environmental analysis was conducted to evaluate the potential for contaminants released at the surface to reach the Mint Farm Wellfield, based on the groundwater model. Changes to shallow groundwater flow patterns and potential threats to groundwater quality caused by 12 mgd average annual pumping at the Mint Farm Wellfield were evaluated with three model scenarios.

In the first scenario, forward particle tracking from identified potentially contaminating activities (PCAs) indicated that groundwater flow paths from these PCAs do not extend beyond the surficial soil or the silt/clay confining layer during the 30-year time frame modeled. The model simulation indicated that pumping at the Mint Farm Wellfield does not noticeably alter the shallow groundwater flow patterns. Groundwater flow in the shallow aquifer during full build-out pumping at the Mint Farm Wellfield is still primarily directed towards the CDID drainage ditches.

Two hypothetical worst-case contamination simulations were modeled to evaluate the potential for contaminants to reach the aquifer. For these simulations, a constant concentration source was applied over a large area set at a hypothetical value of 100 percent in the shallow aquifer. One area was the Mint Farm Industrial Park and the other was the Weyerhaeuser and Millennium Bulk Terminal (formally Chinook Ventures and Reynolds Aluminum) area. This defines a hypothetical worst-case scenario of widespread contamination. By using a value of 100 percent, the pathway analysis can evaluate the percentage of the shallow aquifer water that reaches the Mint Farm Wellfield.

For both the Mint Farm and Weyerhaeuser/Millennium scenarios, the maximum percentage of the surface contamination found in any Mint Farm production well after 30 years was 0.000001 percent or eight orders of magnitude smaller than the concentration at the surface. This value is essentially a mathematical artifact of the use of numerical methods. For all practical purposes, these results indicate that contaminants at the surface would not reach the Mint Farm Wellfield. Therefore, the modeling does not identify any complete pathways between potentially contaminating activities in the Mint Farm area and the deep groundwater aquifer.

The shallow and unconfined areas above the deep aquifer and between the river and the Mint Farm wells do not contribute to the target gravel unit and it is unlikely that a surface contaminant would penetrate into the deep aquifer. Additionally, higher pressure in the deeper aquifer would prevent a contaminant from traveling from the shallow aquifer down into the deep aquifer.

1.3.2.6 Wellhead Protection Plan (WHPP)

1.3.2.6.1 Survey Form and Source Area Delineation

The DOH requires completion of a Susceptibility Assessment Survey Form for each new and existing well used as a source of drinking water. The form was developed to assist the water utility and the state in evaluating the hydrologic setting of the water source and assessing the source's overall susceptibility to contamination from surface activities. This form has been completed for each well and is included in the sections of this document pertaining to the individual wells.

The WHPP also requires delineation of the source areas. Figure 6 provides an illustration of the time of travel delineations determined by the groundwater model for the Mint Farm wells. Water from the Columbia River percolates into the deep water-bearing gravel and travels thousands of feet to the Mint Farm Wellfield. Therefore, the City's wellhead protection plan is focused as follows:

- In all likelihood, a spill of light non-aqueous phase liquid (LNAPL) would float on the river surface and would not impact the deep aquifer. However, major spills consisting of dense non-aqueous phase liquid (DNAPL) could sink to the river bottom and present some concern. In both cases however, the compound would be flushed downstream rapidly. The City will track the response to reported major spills in the Columbia and follow-up water quality monitoring.

- Protective measures within the wellhead protection zone will focus on preventing construction or drilling methods that could penetrate to the deeper aquifer, such as pilings, piers, or other penetrations for new buildings and structures.

- The prevention of spills or surface contamination of any kind within the wellhead protection zone is essential, even if the likelihood of penetration to the deep aquifer is remote. This is typically already addressed by building, fire, and hazardous material codes, but the WHPP will ensure an adequate level of protection is provided.

1.3.2.6.2 Potential Contamination Sources of Concern

An inventory of potential sources of groundwater contamination in the delineated time-of-travel zones is an essential element of wellhead protection. Phase I and II Environmental Site Assessments (ESAs) were completed in 2009 to assess site conditions for the Mint Farm Wellfield. Numerous sites that may pose environmental risks were listed on various state and federal records and are included on a list of potential sources of contamination. There are several deep aquifer wells within the assessment area. Weyerhaeuser, who has three deep gravel aquifer wells, has been contacted and is considering decommissioning these wells. Millennium Bulk Terminals has been contacted to initiate plans for protection of their nine deep wells. At this time, Millennium Bulk Terminals does not have plans to abandon any of their wells and has restored all nine wells to operating condition. Puget Sound Energy has two deep wells, constructed in 2001 and 2002 using modern construction methods that pose little risk of contamination to the City's wellfield. Analytical soil and groundwater data results of the Phase II ESA indicated that organic and inorganic constituents are present in the soils and shallow groundwater in the area; with only a few exceptions, these concentrations are either below their respective comparison levels or are background concentrations.

Because of the thickness of the confining layer above the deep aquifer in the 6-month and 1-year travel zones shown on Figure 6, the primary sources of potential contamination are facilities that extend through the confining layer such as wells, borings, or pilings, and the lower water of the Columbia River itself. The hydraulic gradient of the deep aquifer (the pressure in the water-bearing zone) also serves to protect the aquifer from a spill and or the effects of drilling or pile driving. If the deep aquifer were penetrated, the aquifer pressure would prevent all but the heaviest contaminants from reaching the flowing portion of the aquifer.

Spills, leaks, or discharges of potential contaminants on or near the surface will not directly impact the deeper aquifer. However, these sources of contamination may enter the Columbia River through either the shallow aquifer or the drainage ditches. If surface contamination does reach the Columbia River, the tremendous flow of the river, as well as the fact that the recharge area is at the bottom of the river, minimizes the potential threat.

1.3.2.6.3 Continued Water Quality Monitoring

The placement of the permanent monitoring wells throughout the Mint Farm provides an opportunity for routine groundwater monitoring. The City will continue to sample six of nine deep monitoring wells to provide an early indicator of potential wellfield contamination. The continued monitoring program is described in further detail in Section 1.4.9.

1.3.2.7 Conclusions on Aquifer Characteristics

- ***Shallow and deep aquifers.*** Groundwater in the Longview-Kelso Basin consists of shallow and deep aquifer systems. The deep aquifer system is further subdivided into a gravel aquifer and a sand aquifer. The sand aquifer underlies the majority of the eastern and northern Longview-Kelso Basin. The gravel aquifer is limited to the southwestern portion of the basin, and this aquifer is the target aquifer for the Mint Farm water supply.
  - The shallow aquifer system is primarily recharged from precipitation and secondarily from the Cowlitz River. Discharge from the shallow aquifer system is to the CDID drainage ditches.
  - The deep gravel aquifer is primarily recharged from the Columbia River, whereas the deep sand aquifer is primarily recharged from the Cowlitz River and secondarily from precipitation. Groundwater in the deep aquifer system ultimately discharges through the sand aquifer and lower permeability materials to the CDID drainage ditches.
- ***A barrier exists between shallow and deep aquifers.*** A confining layer consisting of silt and clay layers overlies the eastern two-thirds of the Longview-Kelso Basin. The confining layer serves as a barrier that restricts the movement of groundwater between the shallow and deep aquifer systems.
- ***Groundwater modeling showed minimal drawdown.*** Groundwater modeling conducted to evaluate the sustainability of long-term pumping from the deep gravel aquifer for the Mint Farm Wellfield calculated approximately 6 feet of drawdown to meet the City's 50-year maximum day demand. That drawdown is a very small amount compared to the volume of water being withdrawn, and is limited to a close proximity to each well. Test pumping of a production well showed no drawdown impact 60 feet or more away from the well. The source of water to the Mint Farm Wellfield was found to be the Columbia River, transmitted through the gravel aquifer. Source water enters the aquifer at locations where the Columbia River has cut through the clay and silt layers and the channel intersects the gravel unit west of the Mint Farm site.
- ***Planned pumping rates are sustainable.*** The Mint Farm Wellfield is capable of sustaining the planned pumping rates.
- ***Modeled travel times from source.*** Groundwater modeling indicates that travel times for water from the Columbia River source areas to reach the Mint Farm Wellfield range from approximately 2 years to over 10 years at an average daily demand of 12 mgd

(Figure 6.) The 12 mgd figure was the 50-year ADD using 2005 Water System Plan projections. City water consumption has decreased in the past few years and the 2032 Water System Plan 20-year MFRWTP ADD projection is only 6.6 mgd (6.4 mgd with conservation).

- ***Analyses showed surface contaminants would not reach production wells.*** Wellfield recharge pathway analyses were conducted for three different water demand scenarios to evaluate the potential for contaminants released at the surface to reach the Mint Farm production wells. The results indicate that no contamination reached the Mint Farm production wells within 30-year time frame modeled.

1.3.2.8 Conclusions of Water Quality and Environmental Risk Assessment

- ***No constituents of concern detected above screening levels in deep groundwater.*** Samples of shallow Mint Farm soil, the Columbia and Cowlitz Rivers, shallow and deep groundwater monitoring wells, and a test production well, were analyzed for over 300 constituents identified as constituents of concern based on drinking water regulations, historical activities in the area, and unregulated contaminants of emerging concern. No analytes were detected in any deep groundwater samples at concentrations above their respective screening levels. Twice annual monitoring of monitoring wells DW-1, -2, -5, -6, -7, and -9 will continue to assure a safe and reliable supply.

- ***Deep aquifer and river sources would meet all drinking water quality regulations.*** The Environmental Risk Assessment results indicate that with appropriate treatment, the deep aquifer and the Columbia and Cowlitz Rivers would meet all state and federal water quality regulations as safe sources of drinking water supply.

- ***Naturally occurring iron and manganese need treatment.*** At the levels detected in the deep aquifer, removal of iron and manganese (naturally occurring groundwater constituents) is desirable to prevent objectionable aesthetic concerns.

- ***Arsenic detected below health-based screening level.*** In the deep groundwater, arsenic was detected below the health-based screening level, but above the level at which the state requires reporting in the annual CCR. The proposed treatment process for iron and manganese removal will also remove arsenic to a level below that requiring identification in the CCR.

1.3.2.9 Conclusions for Wellhead Protection Planning Purposes

- ***Deep aquifer would not be impacted by surface contaminants.*** Spills, leaks, or discharges of potential contaminants on or near the surface at the Mint Farm Industrial Park or the industrial areas for Weyerhaeuser and Millennium Bulk Terminal (formally Chinook Ventures and Reynolds Aluminum) will not directly impact the deep aquifer due primarily to the presence of the silt/clay confining layer.

- ***Minimal potential threat of river entrance for contaminants.*** Potential sources of contamination may enter the deep aquifer through the Columbia River. However, the tremendous flow of the Columbia River, as well as the fact that the recharge area is at the bottom of the river, will dilute and flush away most any contaminant and minimize the potential threat to the Mint Farm deep aquifer.

1.3.3 PDR Part 3 – Environmental Permitting and Archaeological Investigations

As required by the DOH, Washington State Department of Archaeology and Historic Preservation (DAHP), and the National Environmental Protection Act (NEPA), a permitting process for environmental and archeological concerns was initiated. There are two basic processes required for the permitting of a facility such as a water supply and treatment plant at the Mint Farm. The State Environmental Protection Act (SEPA) provisions are normally required for State-funded projects constructed within Washington State, and the NEPA, a federal permitting process, is required for projects obtaining federal funding. The Mint Farm water supply project falls under both NEPA and SEPA requirements; however, the local agency can adopt the NEPA findings to support the SEPA determination.

Archaeological site assessment is a relatively new requirement for all projects in Washington. A licensed or a state-certified archaeologist must investigate project sites such as the Mint Farm to establish the absence of any historical or prehistoric activities on the site. More commonly, these would be tribal activities.

Environmental permitting and archaeological investigation efforts are complete and a Finding of No Significant Impact (FONSI) was issued by the EPA. General findings to date are:

- The Mint Farm project site is a previously disturbed site with mitigated wetlands. Except for the presence of existing man-made wetlands, there are no other regulated wetlands in the construction area.

- There appear to be no major constraints from a permitting perspective for the construction of the new Mint Farm RWTP or an associated pipeline due to environmental conditions; the alternative to build new will have less impact to the environment than doing in-water work in the Cowlitz River necessary to keep the existing RWTP in use.

No historical or prehistoric remnants were found as a result of the archaeological work conducted for this project. Landau Associates archaeological probes were conducted every 30 meters in and around the proposed treatment plant site, as well as along the proposed alignment of the pipeline connecting the treatment plant to the existing distribution system.

1.4 Well Water Quality

1.4.1 Preliminary Water Quality Sampling Approach

The City developed a water quality sampling plan early in the project. This sampling included soil and shallow well samples used in the ESA and groundwater samples collected from the newly drilled deep monitoring wells, the production wells, and other existing wells in the Mint

Farm Industrial Park. Samples were also collected from the Cowlitz River and the Columbia River as a comparison to the groundwater supply. As part of the ESA, a HHRA was completed to assess potential health risks from each of the three potential sources of supply under consideration.

1.4.2 Environmental Risk Assessment

The ESA was performed in two phases. Phase 1 involved researching, collecting, and analyzing available data concerning prior industrial and agricultural activities in the Mint Farm Industrial Park to identify contaminants of potential concern. In Phase II of the ESA, 11 boring locations were selected for collection of shallow (0 to 6 inches bgs) and deep (just above groundwater, approximately 10 to 20 feet bgs) soil samples. The objective of the sampling was to identify potential contaminants in the vicinity of the proposed production wells associated with historical activities. This analysis resulted in the conclusion that the site is an appropriate location for the MFRWTP.

1.4.3 Sampling Protocol

Three different types of samples were collected as follows:

1. **Phase II ESA Samples**. As part of the Phase II ESA, soil and groundwater samples were collected to identify potential contaminants in the vicinity of the proposed production wells associated with historical industrial and agricultural activities in the area.

2. **Groundwater Samples**. The groundwater was sampled at each of the nine newly constructed deep monitoring wells (DW1 through DW9), the first production well (PW1), the Puget Sound Energy well, and a well on the Chinook Ventures site.

3. **Surface Water Source Samples**. The Columbia River and Cowlitz River surface waters were also sampled to provide a snapshot of water quality in these sources at the time of initial sampling of the groundwater.

1.4.4 Human Health Risk Assessment

An HHRA was performed as part of the ESA to characterize the water quality of the Mint Farm deep aquifer and to determine if any potential health risk could be identified with use of the groundwater aquifer as a drinking water source.

A screening level risk evaluation was conducted and detected concentrations of the analytes were compared directly against health-based screening levels for drinking water. For chemicals not regulated in drinking water, appropriate screening levels were determined from technical information about the specific chemical. The presence of a chemical at concentrations below its screening level can generally be assumed not to pose a significant, long-term (chronic) or short-term (acute) threat to human health. The screening levels were established from the following water quality standards:

- MCLs – Maximum Contaminate Levels as established by U.S. Environmental Protection Agency (EPA) and adapted by the DOH (WAC 246-290)

- WA WQC – Water Quality Standards for Ground Waters of the State of Washington (WAC 173-200)
- MTCA – Model Toxics Control Act – Method B (WAC 173-340)
- EPA RSL – U.S. EPA Regional Screening Levels for Tap Water (2009).

1.4.5 Analytes Selected for Water Quality Testing

In order to thoroughly address potential public health risks and to perform the HHRA, the sampling was organized into three sample tiers. The three tiers were as follows:

- Tier 1 – Contaminants of potential concern due to historical agricultural and industrial activity in the vicinity of the current Mint Farm Industrial Park.
- Tier 2 – Contaminants currently regulated in drinking water at the State and National levels, parameters relating to physical and chemical characteristics of the waters, and synthetic organic chemicals that could be analyzed by extending analytical methods that were used to analyze for regulated contaminants.
- Tier 3 - The Tier 3 analytes included chemicals currently not regulated in drinking water but are under scrutiny for potential future regulation. The Tier 3 analytes were divided into four categories.
  - Category 1 - Synthetic organic chemicals, in addition to those included in extensions of the analytical methods for regulated chemicals.
  - Category 2 - Compounds that are endocrine disruptors and personal care products that are primary indicators of potential wastewater impacts.
  - Category 3 - Additional endocrine disruptors and personal care products.
  - Category 4 – Compounds that are in a class of flame-retardants, termed polybrominated diphenyl ethers.

1.4.6 Preliminary Water Quality Sampling Results

The results are summarized in Table A. No analytes were detected in any deep groundwater samples at concentrations above their respective screening levels. Arsenic concentrations in the deep groundwater aquifer were below the screening level 10 µg/L, but some samples were above the level that triggers reporting in the City's annual CCR on drinking water quality (5 µg/L). Additionally, iron and manganese were found at concentrations that are not a human health concern, but treatment would be required to prevent objectionable aesthetic issues. The proposed treatment process to remove iron and manganese will also remove arsenic such that the treated water will consistently have an arsenic concentration of less than 5 µg/L.

1.4.7 Preliminary Water Quality Conclusions

The water quality results indicated that, with appropriate treatment, the deep aquifer will meet all state and federal water quality regulations and it will provide a safe source of drinking water supply. The removal of iron and manganese (naturally occurring groundwater constituents) is desirable to prevent aesthetic issues and meet state regulations. Based on the results of the groundwater modeling, the water quality of the deep groundwater is not anticipated to change significantly in the future from that evaluated in the ESA.

Table A: Summary of 2009 Water Quality for Human Health Risk Assessment, Mint Farm Industrial Park Area - City of Longview, Washington

							Surface Water		Deep Groundwater Aquifer																	
				Location / Date	Screening Level		RSW-1 (Columbia River) 06/08/2009	RSW-3 (Cowlitz River) 06/08/2009	RSW-2 (Puget Sound Energy) 06/08/2009	Millenium Bulk (Chinook V) 07/14/2009	PW-1 10/05/2009	PW-1 11/04/2009	PW-1 11/11/2009	DW-9 08/13/2009	DW-9 11/12/2009	DW-8 06/09/2009	DW-7 06/10/2009	DW-7 11/12/2009	DW-6 06/10/2009	DW-5 06/11/2009	DW-4 06/11/2009	DW-3 06/12/2009	DW-2 06/12/2009	DW-1 06/09/2009	DW-1 11/11/2009
Method	Tier	Analyte	Cas #	Units	Value	Source	Result	Result	Result	Result	Result	Result	Result	Result	Result	Result	Result	Result	Result	Result	Result	Result	Result	Result	Result
General Parameters																									
A2120B	2a	Color, Apparent	COLOR	color unit	--	NR	10	10	5	5	25	20	15	10	20	5	ND	25	ND	10	10	10	5	10	15
A2320B	2a	Alkalinity, Total (As CaCO3)	ALK	mg/l	--	NR	43	27	104	164	105	102	104	112	89	112	86	87	112	112	170	163	133	85	85
A2340B	2a	Hardness As CaCO3	HARDNESS	mg/l	--	NR	43.2	24	87.8	140	99	87	88	92.9	70	87.9	72.5	74	85.9	99.2	134	151	103	69.8	74
A2510B	2a	Conductivity	COND	umhos/cm	--	NR	128	83	247	376	240	232	228	435	194	239	197	191	239	273	377	407	293	194	189
A2540C	2a	Total Dissolved Solids (Residue, Filterable)	TDS	mg/l	--	NR	62	55	164	235	187	166	175	161	145	160	150	147	161	165	233	247	182	160	144
A4500SIO2(	2a	Silica	7631-86-9	mg/l	--	NR	10.7	23.9	58.8	43.1	51	59	59	59.7	55	76.9	70.3	55	64.2	67	54.3	72.5	52.6	74.7	55
A5310C	2a	Total Organic Carbon	TOC	mg/l	--	NR	2.2	1.3	0.8	1.9	1.62	1.45	1.29	1.9	1.2	1.5	1.4	1.17	2.5	2.3	4.3	1.8	2.1	1.3	1.28
A5910B	2a	UV254	CASID10075	cm -1	--	NR	33.4	40.9	29	0.048	0.039	0.04	0.05	0.037	0.055	0.04	0.04	0.054	0.03	0.03	0.05	0.04	0.04	0.06	0.053
E150.1	2a	pH	pH	pH units	--	NR	7.55	7.54	7.56	7.73	7.34	7.91	7.37	7.78	7.38	7.61	7.53	7.22	7.83	8.04	7.55	7.83	8.05	7.46	7.26
E180.1	2a	Turbidity	TURBIDITY	ntu	--	NR	6	8	3.6	3.9	2.97	2.01	1.28	3.3	0.99	6.7	3.3	2.58	1.3	0.5	33.7	4.2	11.5	8.8	12
Microbial Parameters																									
A9221E	2a	Fecal Coliform	FECCOLI	mpn/100ml	--	NR	ND	11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
A9223B	2a	Coliform	COLIF	mpn/100ml	--	NR	205	210	ND	ND	7.4	1.0	ND	2	ND	7	12	ND	1	22	248	ND	7	ND	ND
Contaminants To Be Removed Using Treatment																									
E200.8	2a	Arsenic	7440-38-2	µg/l	10	MCL	0.85	ND	7.24	7.6	6.1	5.7	5.85	3.46	4.14	9.17	2.95	4.3	2.29	3.75	6.32	5.82	4.88	2.44	3.77
E200.7	2a	Iron	7439-89-6	µg/l	26,000	EPA RSL[2]	358	492	1,110	808	1,050	867	901	1,060	637	1,840	1,220	1,220	450	308	5,030	966	895	2,250	2,370
E200.7	2a	Manganese	7439-96-5	µg/l	2,200	MTCA Method B[2]	17.2	17	498	415	681	554	574	587	513	593	671	662	371	233	804	377	216	605	548
Naturally Occurring Minerals and Salts																									
E200.7	2a	Calcium	7440-70-2	µg/l	--	NR	11,300	7,100	24,400	36,900	28,200	23,900	25,500	26,500	22,600	24,800	20,800	21,600	24,100	26,400	41,900	44,600	27,000	20,200	21,500
E200.7	2a	Magnesium	7439-95-4	µg/l	--	NR	3,630	1,530	6,530	11,500	7,020	6,670	5,790	6,500	5,010	6,280	4,950	4,950	6,270	8,070	7,030	9,730	8,660	4,740	4,810
E200.7	2a	Potassium	7440-09-7	µg/l	--	NR	1,170	584	4,040	5,040	3,570	3,620	3,250	3,620	3,200	4,140	3,010	2,950	3,670	4,050	3,740	3,960	5,610	2,730	2,650
E200.7	2a	Silicon	SI	µg/l	--	NR	5,630	7,550	24,100	21,500	26,400	27,200	24,700	24,600	25,300	22,600	23,200	24,200	21,100	20,400	24,000	21,500	17,900	23,400	24,500
E200.7	2a	Sodium	7440-23-5	µg/l	--	NR	9,470	5,030	9,580	16,400	11,000	10,100	9,280	10,300	8,890	11,500	8,990	8,620	10,800	12,000	23,700	18,800	14,000	8,650	8,850
E300	2a	Bromide	BROMIDE	mg/l	--	NR	ND	ND	0.2	ND	NA	NA	NA	ND	ND	NA	NA	ND	NA	NA	0.2	0.2	NA	0.2	ND
E300	2a	Chloride	CHLORIDE	mg/l	--	NR	5.4	3.3	12.1	19.2	8.36	7.48	7.56	6.5	5.28	7.9	5.7	6.3	12.3	16.4	18.7	32.4	12.1	5.4	5.17
E300	2a	Fluoride	FL_T	mg/l	4	MCL	ND	ND	0.2	0.3	ND	0.21	0.24	ND	0.27	ND	0.3	0.28	0.2	ND	ND	ND	0.3	0.2	0.31
E300	2a	Nitrogen, Nitrate (As N)	N_NO3	mg/l	10	MCL	0.4	0.3	ND	ND	ND	ND	ND	ND	ND	0.3	0.3	ND	0.3	0.3	0.3	0.3	ND	0.3	ND
E300	2a	Nitrogen, Nitrite	NO2N	mg/l	1	MCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1	ND	ND	ND	ND	ND	ND	ND	ND
E350.1	2a	Nitrogen, Ammonia (As N)	N_NH3	mg/l	--	NR	ND	ND	0.28	0.26	0.194	0.197	0.213	0.13	ND	0.34	0.25	0.232	0.1	ND	0.51	0.16	ND	0.32	0.345
E365.3	2a	Phosphate, Ortho-	14265-44-2	mg/l	--	NR	0.03	0.03	0.58	0.35	NA	NA	NA	0.41	NA	0.25	0.35	NA	0.45	0.53	0.09	0.21	0.34	0.17	NA
E365.3	2a	Phosphorus, Total (As P)		mg/l		NR	NA	NA	NA	NA	NA	NA	0.585	NA	0.566	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E365.3	2a	Phosphorus, Total Orthophosphate (As P)		mg/l		NR	NA	NA	NA	NA	0.329	0.346	0.575	NA	0.386	NA	NA	0.247	NA	NA	NA	NA	NA	NA	0.102
E300	2a	Sulfate	SULFATE	mg/l	--	NR	6.9	5.8	0.3	0.2	0.45	0.57	0.6	0.4	1.42	0.3	2.4	1.61	1.7	0.7	1	0.5	3.4	1.6	1.26
Metals																									
E200.7	2a	Aluminum	7429-90-5	µg/l	37,000	EPA RSL	392	704	54	ND	ND	ND	2.3	23.2	2.5	4.3	4.7	ND	47.6	23.2	1,460	37.9	435	4.3	ND
E200.7	2a	Zinc	7440-66-6	µg/l	4,800	MTCA Method B	22.3	ND	ND	ND	ND	ND	ND	3.6	ND	2.3	ND	ND	ND	ND	8.5	ND	ND	ND	ND
E200.8	2a	Antimony	7440-36-0	µg/l	6	MCL	0.12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.07	ND	ND
E200.8	2a	Barium	7440-39-3	µg/l	2,000	MCL	18.1	4.01	20.4	25.7	14	12	13	13.8	10	25.1	12.9	11	12.5	13.2	24.8	30.9	27.7	12	11
E200.8	2a	Beryllium	7440-41-7	µg/l	4	MCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.043	ND	0.021	ND	ND
E200.8	2a	Cadmium	7440-43-9	µg/l	5	MCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.029	ND	0.039	ND	ND
E200.8	2a	Chromium, Total	7440-47-3	µg/l	100	MCL	0.34	0.26	ND	ND	ND	0.2	ND	0.73	ND	ND	ND	ND	ND	ND	2.59	ND	0.63	ND	0.27
E200.8	2a	Copper	7440-50-8	µg/l	1,300	MCL	1.48	2.08	0.33	0.15	0.2	ND	ND	0.3	ND	ND	ND	ND	ND	ND	2.27	0.17	0.8	ND	ND
E200.8	2a	Lead	7439-92-1	µg/l	15	MCL	0.267	0.105	0.061	ND	ND	ND	ND	0.05	ND	ND	ND	ND	0.033	ND	0.355	0.022	0.177	ND	ND
E200.8	2a	Nickel	7440-02-0	µg/l	100	MCL	0.45	0.34	0.26	0.48	0.6	0.7	0.67	1.68	0.63	0.86	0.77	0.61	0.91	0.96	2.59	1.51	1.26	0.74	0.57
E200.8	2a	Silver	7440-22-4	µg/l	50	WA GQC	ND	ND	ND	ND	0.07	0.08	0.033	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
E200.8	2a	Uranium	U	µg/l	30	MCL	0.375	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.025	ND	0.052	ND	ND	ND	ND
Volatile and Synthetic Organics																									
E524.2	2a	Chloroform	00067-66-3	µg/l	80	MCL (total trihalomethanes)	ND	ND	ND	ND	NA	NA	NA	ND	ND	ND	ND	ND	0.86	ND	ND	ND	2.4	ND	ND
E525.2	2a	Bis(2-Ethylhexyl) Phthalate	00117-81-7	µg/l	6	MCL	ND	ND	ND	ND	ND	ND	ND	0.68	ND	ND	ND	ND	ND	ND	1	ND	ND	ND	ND
E525.2	2b	Dioctyl Adipate	103-23-1	µg/l	56	EPA RSL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.8	ND	ND	ND	ND
E525.2	2b	Fluoranthene	00206-44-0	µg/l	640	MTCA Method B	ND	ND	ND	ND	NA	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
E525.2	2b	Isophorone	00078-59-1	µg/l	46	MTCA Method B	ND	ND	ND	ND	NA	NA	NA	ND	ND	ND	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Radiation																									
E900	2a	Alpha, Gross	ALPHA	pci/l	15	MCL	1.5	1.5	0.79		-0.56	-3.1	0.21			0.28	3.8		0.34	-0.26	0.57	0.47	-0.5	0.37	
E900	2a	Beta, Gross	BETA	pci/l	50	WA GQC (MCL is 4 millirems/year)	3.8	0.85	6.4	4	2.9	1.2	5.0	3.7	1.2	3.6	3.3	2.0	3.9	2.9	4.2	1.6	6.6	2.4	0.7
E903.1	2a	Radium 226	13982-63-3	pci/l	5	MCL (226, 228 combined)	0.13	-0.01	0.04	0.04	0.05	0.15	-0.05	0.27	0.04	-0.04	-0.01	0.01	-0.05	0.04	0.04	0.07	0.01	0.02	0.03
E904.0	2a	Radium 228	15262-20-1	pci/l	5	MCL (226, 228 combined)	0.99	1.5	0.6	-0.18	1.8	2.9	0.9	0.99	1.0	1.1	0.58	1.3	0.22	0.21	1.2	0.63	0.32	0.41	1.1
Contaminants of Emerging Concern[1]																									
E1694M	3	2-Hydroxy-4-Methoxybenzophenone	131-57-7	ng/l	4,655,000	See HHRA TM	ND	ND	ND	ND	NA	NA	NA	8.9	ND	NA	NA	ND	NA	NA	NA	NA	NA	NA	ND
E1694M	3	Bisphenol A	BPHENOLA	ng/l	800,000	MTCA Method B	ND	ND	ND	ND	NA	NA	NA	76	ND	NA	NA	ND	NA	NA	NA	NA	NA	NA	ND
E1694M	3	Caffeine	CAFFEINE	ng/l	87,500,000	See HHRA TM	ND	ND	ND	ND	NA	NA	NA	5.3	ND	NA	NA	ND	NA	NA	NA	NA	NA	NA	ND
E1694M	3	Fluoxetine	54910-89-3	ng/l	3,400	See HHRA TM	4.2	ND	ND	ND	NA	NA	NA	ND	ND	NA	NA	ND	NA	NA	NA	NA	NA	NA	ND
E1694M	3	N,N-Diethyl-3-Methyl Benzamide	134-62-3	ng/l	81,000	See HHRA TM	ND	ND	ND	ND	NA	NA	NA	23	ND	NA	NA	ND	NA	NA	NA	NA	NA	NA	ND
E1694M	3	Sulfamethoxazole	723-46-6	ng/l	151,000	See HHRA TM	2.3	ND	ND	ND	NA	NA	NA	ND	ND	NA	NA	ND	NA	NA	NA	NA	NA	NA	ND

Footnotes:

[1] With the exception of Bisphenol A, these unregulated compounds have been approved for human use as pharmaceuticals or as personal care products. Where detected. these unregulated chemicals were at concentrations of parts per trillion (ppt). Water quality constituents are generally regulated at concentrations of several orders of magnitude greater such as µg/l (parts per billion) and milligrams per liter (mg/l, parts per million). While none of the detected concentrations exceeded available health-based screening levels, the presence of these compounds, especially in groundwater samples, may be attributable to sampling or laboratory contamination.

[2] Washington Dept. of Health regulates iron and manganese due to objectionable aesthetic concerns. The DOH secondary maximum contaminant levels for these metals are:
Iron MCL = 300 µg/l
Manganese MCL = 50 µg/l

General Notes:

Only analytes detected at concentrations greater than or equal to the method reporting limit (MRL) are listed. Concentrations exceeding respective screening levels are shown in **bold** and shaded.

Abbreviations:

NA = not analyzed
ND = not detected at concentrations greater than or equal to MRL
CAS = Chemical Abstract Service
mg/l = milligrams per liter (parts per million)
µg/l = micrograms per liter (parts per billion)
ng/l = nanograms per liter (parts per trillion)
pci/l = picocuries per liter
mpn/100 ml = most probable number (MPN) of bacteria per 100 milliliters (ml) in water
umhos = micromhos
MRL = Method Reporting Limit

Screening Level Sources:

MCL = State or Federal enforceable maximum contaminant level for drinking water.
WA WQC = Washington Administrative Code (WAC) 173-200-040 Table 1 Groundwater Quality Criteria.
MTCA Method B = Washington Department of Ecology (Ecology) Model Toxics Control Act (MTCA) Method B cleanup levels for groundwater.
EPA RSL = United States Environmental Protection Agency (USEPA) Regional Screening Levels for tapwater (April 2009).
NR = Not Regulated

Table B: Summary of 2010 and 2011 Water Quality for Human Health Risk Assessment, Mint Farm Industrial Park Area - City of Longview, Washington

				Location			Deep Groundwater Aquifer								
				Date	Screening Level		PW-2 October 2011	PW-3 October 2011	PW-4 October 2011	DW-1 See Note 3 and 4	DW-2 See Note 3 and 4	DW-5 See Note 3 and 4	DW-6 See Note 3 and 4	DW-7 See Note 3 and 4	DW-9 See Note 3 and 4
Method	Tier	Analyte	Cas #	Units	Value	Source	Result	Result	Result	Average Result	Average Result	Average Result	Average Result	Average Result	Average Result
General Parameters															
A2120B	2a	Color, Apparent	COLOR	color unit	--	NR	15	10	5	15	10	10	20	25	15
A2320B	2a	Alkalinity, Total (As CaCO3)	ALK	mg/l	--	NR	90	98	103	91.3	145	104	98.2	89.1	106
A2340B	2a	Hardness As CaCO3	HARDNESS	mg/l	--	NR	76	83	82.9	69.7	120	131	121	74.4	84.7
A2510B	2a	Conductivity	COND	umhos/cm	--	NR	196	218	216	212	359	389	359	219	252
A2540C	2a	Total Dissolved Solids (Residue, Filterable)	TDS	mg/l	--	NR	157	175	170	167	218	222	239	156	105
A4500SIO2(	2a	Silica	7631-86-9	mg/l	--	NR	53	23	51.2	29.2	44.7	53.9	41.6	49.1	28.9
A5310C	2a	Total Organic Carbon	TOC	mg/l	--	NR	1.04	1.26	0.88	1.00	1.45	1.02	0.94	1.00	1.12
A5910B	2a	UV254	CASID10075	cm -1	--	NR	0.041	0.038	0.034	0.080	0.043	0.032	0.029	0.037	0.049
E150.1	2a	pH	pH	pH units	--	NR	7.46	7.79	7.62	7.35	7.94	7.98	7.52	7.47	7.45
E180.1	2a	Turbidity	TURBIDITY	ntu	--	NR	NA	2.56	2.41	0.63	NA	NA	NA	NA	0.20
Microbial Parameters															
A9221E	2a	Fecal Coliform	FECCOLI	mpn/100ml	--	NR	ND	ND	ND	ND	ND	ND	ND	ND	ND
A9223B	2a	Coliform	COLIF	mpn/100ml	--	NR	5.2	32.3	ND	ND	NA	NA	NA	NA	ND
Contaminants To Be Removed Using Treatment															
E200.8	2a	Arsenic	7440-38-2	µg/l	10	MCL	5.2	6.5	6.2	**4.2**	**7.1**	**6.0**	**4.7**	**4.8**	**5.5**
E200.7	2a	Iron	7439-89-6	µg/l	26,000	EPA RSL[2]	1,770	863	825	**2383**	**551**	**416**	**604**	**1227**	**756**
E200.7	2a	Manganese	7439-96-5	µg/l	2,200	MTCA Method B[2]	583	491	504	**575**	**272**	**297**	**479**	**662**	**598**
Naturally Occurring Minerals and Salts															
E200.7	2a	Calcium	7440-70-2	µg/l	--	NR	21,300	23,700	23,600	**21,167**	**32,133**	**32,775**	**31,680**	**21,400**	**25,567**
E200.7	2a	Magnesium	7439-95-4	µg/l	--	NR	5,350	5,830	5,830	**5,077**	**10,733**	**10,373**	**8,618**	**5,187**	**6,097**
E200.7	2a	Potassium	7440-09-7	µg/l	--	NR	2,910	3,400	3,380	**2,717**	**5,833**	**4,463**	**4,174**	**3,023**	**3,557**
E200.7	2a	Silicon	SI	µg/l	--	NR	26,500	25,800	26,100	**26,167**	**20,900**	**23,325**	**24,940**	**25,467**	**26,867**
E200.7	2a	Sodium	7440-23-5	µg/l	--	NR	8,790	9,000	8,890	**8,797**	**15,300**	**12,425**	**11,240**	**8,757**	**9,713**
E300	2a	Bromide	BROMIDE	mg/l	--	NR	NA	NA	NA	NA	NA	NA	NA	NA	NA
E300	2a	Chloride	CHLORIDE	mg/l	--	NR	5.88	7.41	7.47	4.61	16.0	41.2	40.8	6.85	7.53
E300	2a	Fluoride	FL_T	mg/l	4	MCL	ND	ND	ND	ND	ND	ND	ND	ND	ND
E300	2a	Nitrogen, Nitrate (As N)	N_NO3	mg/l	10	MCL	ND	ND	ND	ND	ND	ND	ND	ND	ND
E300	2a	Nitrogen, Nitrite	NO2N	mg/l	1	MCL	ND	ND	ND	ND	ND	ND	ND	ND	ND
E350.1	2a	Nitrogen, Ammonia (As N)	N_NH3	mg/l	--	NR	0.356	0.249	0.292	0.422	0.055	0.070	0.113	0.270	0.167
E365.3	2a	Phosphate, Ortho-	14265-44-2	mg/l	--	NR	0.592	0.598	0.596	NA	NA	NA	NA	NA	NA
E365.3	2a	Phosphorus, Total (As P)		mg/l		NR	0.582	NA	NA	NA	NA	NA	NA	NA	NA
E365.3	2a	Phosphorus, Total Orthophosphate (As P)		mg/l		NR	NA	NA	NA	0.563	0.465	0.476	0.480	0.531	0.574
E300	2a	Sulfate	SULFATE	mg/l	--	NR	0.76	0.62	0.53	1.22	ND	ND	ND	1.61	ND
Metals															
E200.7	2a	Aluminum	7429-90-5	µg/l	37,000	EPA RSL	2.8	6.5	3.6	**1.5**	**31.7**	**2.1**	**11.0**	**1.0**	**2.1**
E200.7	2a	Zinc	7440-66-6	µg/l	4,800	MTCA Method B	ND	ND	ND	**ND**	**ND**	**ND**	**1.2**	**1.9**	**1.4**
E200.8	2a	Antimony	7440-36-0	µg/l	6	MCL	ND	ND	ND	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
E200.8	2a	Barium	7440-39-3	µg/l	2,000	MCL	13	11	10.8	**11.5**	**24.2**	**14.5**	**15.0**	**10.9**	**12.2**
E200.8	2a	Beryllium	7440-41-7	µg/l	4	MCL	ND	ND	ND	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
E200.8	2a	Cadmium	7440-43-9	µg/l	5	MCL	ND	ND	ND	**ND**	**ND**	**ND**	**ND**	**ND**	**0.01**
E200.8	2a	Chromium, Total	7440-47-3	µg/l	100	MCL	ND	ND	ND	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
E200.8	2a	Copper	7440-50-8	µg/l	1,300	MCL	ND	1.9	ND	**0.17**	**0.17**	**0.11**	**0.11**	**0.43**	**0.10**
E200.8	2a	Lead	7439-92-1	µg/l	15	MCL	ND	0.09	ND	**ND**	**0.02**	**ND**	**0.02**	**0.13**	**0.01**
E200.8	2a	Nickel	7440-02-0	µg/l	100	MCL	0.2	ND	ND	**0.6**	**0.9**	**0.8**	**0.9**	**0.6**	**0.7**
E200.8	2a	Silver	7440-22-4	µg/l	50	WA GQC	ND	ND	ND	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
E200.8	2a	Uranium	U	µg/l	30	MCL	NA	NA	NA	**ND**	**ND**	**ND**	**0.02**	**ND**	**ND**
Volatile and Synthetic Organics															
E524.2	2a	Chloroform	00067-66-3	µg/l	80	MCL (total trihalomethanes)	ND	ND	ND	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
E525.2	2a	Bis(2-Ethylhexyl) Phthalate (Di(ethylhexyl)phthalate)	00117-81-7	µg/l	6	MCL	ND	ND	ND	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
E525.2	2b	Dioctyl Adipate (Di(ethylhexyl)adipate)	103-23-1	µg/l	56	EPA RSL	ND	ND	ND	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
E525.2	2b	Fluoranthene	00206-44-0	µg/l	640	MTCA Method B	NA	NA	NA	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
E525.2	2b	Isophorone	00078-59-1	µg/l	46	MTCA Method B	NA	NA	NA	NA	NA	NA	NA	NA	NA
Radiation															
E900	2a	Alpha, Gross	ALPHA	pci/l	15	MCL	0.9	0.0	0.0	0.16	2.1	0.52	0.74	-0.13	0.77
E900	2a	Beta, Gross	BETA	pci/l	50	WA GQC (MCL is 4 millirems/year)	2.8	2.6	1.7	4.1	7.3	5.1	5.6	3.1	4.5
E903.1	2a	Radium 226	13982-63-3	pci/l	5	MCL (226, 228 combined)	0.29	0.57	0.24	0.15	0.16	0.63	0.06	0.18	-0.02
E904.0	2a	Radium 228	15262-20-1	pci/l	5	MCL (226, 228 combined)	0.62	0.93	0.3	0.52	0.40	0.02	0.23	0.06	0.45
Contaminants of Emerging Concern[1]															
E1694M	3	2-Hydroxy-4-Methoxybenzophenone	131-57-7	ng/l	4,655,000	See HHRA TM	NA	NA	NA	NA	NA	NA	NA	NA	NA
E1694M	3	Bisphenol A	BPHENOLA	ng/l	800,000	MTCA Method B	NA	NA	NA	NA	NA	NA	NA	NA	NA
E1694M	3	Caffeine	CAFFEINE	ng/l	87,500,000	See HHRA TM	NA	NA	NA	NA	NA	NA	NA	NA	NA
E1694M	3	Fluoxetine	54910-89-3	ng/l	3,400	See HHRA TM	NA	NA	NA	NA	NA	NA	NA	NA	NA
E1694M	3	N,N-Diethyl-3-Methyl Benzamide	134-62-3	ng/l	81,000	See HHRA TM	NA	NA	NA	NA	NA	NA	NA	NA	NA
E1694M	3	Sulfamethoxazole	723-46-6	ng/l	151,000	See HHRA TM	NA	NA	NA	NA	NA	NA	NA	NA	NA

Footnotes:

[1] With the exception of Bisphenol A, these unregulated compounds have been approved for human use as pharmaceuticals or as personal care products. Where detected. these unregulated chemicals were at concentrations of parts per trillion (ppt). Water quality constituents are generally regulated at concentrations of several orders of magnitude greater such as µg/l (parts per billion) and milligrams per liter (mg/l, parts per million). While none of the detected concentrations exceeded available health-based screening levels, the presence of these compounds, especially in groundwater samples, may be attributable to sampling or laboratory contamination.

[2] Washington Dept. of Health regulates iron and manganese due to objectionable aesthetic concerns. The DOH secondary maximum contaminant levels for these metals are:
Iron MCL = 300 ug/l
Manganese MCL = 50 ug/l

[3] Values in bold are the averages from sampling events during May 2010, November 2010 and May 2011. Average ND values are input as half of the MRL.

[4] Non-bolded values are taken from the December 2011 sampling event. These constituents only tested in 2011.

General Notes:

Only analytes detected at concentrations greater than or equal to the method reporting limit (MRL) are listed.

Abbreviations:

NA	= not analyzed
ND	= not detected at concentrations greater than or equal to MRL
CAS	= Chemical Abstract Service
mg/l	= milligrams per liter (parts per million)
µg/l	= micrograms per liter (parts per billion)
ng/l	= nanograms per liter (parts per trillion)
pci/l	= picocuries per liter
mpn/100 ml	= most probable number (MPN) of bacteria per 100 milliliters (ml) in water
umhos	= micromhos
MRL	= Method Reporting Limit

Screening Level Sources:

MCL	= State or Federal enforceable maximum contaminant level for drinking water.
WA WQC	= Washington Administrative Code (WAC) 173-200-040 Table 1 Groundwater Quality Criteria.
MTCA Method B	= Washington Department of Ecology (Ecology) Model Toxics Control Act (MTCA) Method B cleanup levels for groundwater.
EPA RSL	= United States Environmental Protection Agency (USEPA) Regional Screening Levels for tapwater (April 2009).
NR	= Not Regulated

1.4.8 Water Quality Sampling at Production Wells 2, 3, and 4

After the preliminary sampling, three additional production wells, PW-2, PW-3, and PW-4 were drilled and developed. Each of these wells was sampled following well flushing and pump testing. The results are summarized in Table B. The well water quality among the four production wells is very similar, with essentially the same physical and chemical characteristics. The concentration of iron was somewhat higher in PW-2, although this may be an outlier and this concentration may fall in line with the values from the other production wells with further pumping. Diquat was detected in PW-3 at a concentration of 1.6 µg/L, well below the MCL of 20 µg/L. Diquat was not detected in any of the previous sampling conducted for the monitoring or production wells, indicating the PW-3 result may have been an anomaly given that diquat was also detected in the field blank. Additional water quality sampling for diquat was performed for all of the production wells in July 2012 in order to confirm the previous analysis. Diquat was not detected in any of the production wells in the July 2012 event; all sample results were Non-Detect (ND). The results are included in the water quality sections for each respective well.

1.4.9 Ongoing Groundwater Sampling

The placement of permanent monitoring wells throughout the Mint Farm provides the opportunity for routine groundwater monitoring. Monitoring wells DW-1, DW-2, DW-5, DW-6, DW-7, and DW-9 were selected for twice annual water quality sampling. Based upon the groundwater modeling, these monitoring wells provide the best early indicator of potential wellfield contamination. The twice annual sampling consists of:

- All regulated and unregulated (as identified in the Unregulated Contaminant Monitoring Rule) drinking water analytes
- Analytes selected based on historical industrial and agricultural activities in the area
- Contaminants of emerging concern.

1.4.10 Pre-Startup Well Water Quality Sampling

Sampling conducted for inorganic chemicals (IOCs), volatile organic chemicals (VOCs), and synthetic organic chemicals (SOCs) in PW-1, PW-2, PW-3, and PW-4 will be sufficient for start-up.

The following sampling will be completed prior to startup:

- Bacteriological sample from each production wells prior to water being introduced into the system.
- Iron and manganese samples prior to start-up to provide a bench mark for treatment during startup.
- Arsenic sample to confirm the low levels found during drilling and testing.

The two step sampling sequence described below should be conducted at least 30 days prior to start-up and commissioning.

1. After installation of all production well equipment, disinfect and flush each well to waste in accordance with specification Section 11003 of the construction contract documents. Disinfection will be in accordance with AWWA C654.
2. At the conclusion of the flushing activity described in the previous task, and after checking to ensure the absence of residual chlorine, collect a sample for coliform bacteria, iron, manganese, and arsenic and send to a state certified laboratory for analysis.
3. During the collection of water quality samples described in Task 2, and using the City's HACH analyzer, conduct a field test for iron and manganese. By doing so, the City may confirm the precision and accuracy of the field equipment once certified laboratory results are returned for the iron and manganese sampling.

Treatment Optimization and Additional Start-Up Requirements

Optimization of the treatment process, including iron and manganese removal, chlorine and fluoride dosage requirements, and pH adjustment will be conducted during start-up and commissioning. The Process and Instrumentation Diagram Lab Sampling and Analysis Systems (Construction Drawing P-504) illustrate the location of sample taps in the laboratory where monitoring of process performance parameters may be analyzed.

To confirm the post-treatment water quality the following constituents will be sampled during the commission phase of the project. Results from the commission phase sampling will be provided to DOH for their review and approval prior to sending treated water into the distribution system.

- Iron
- Manganese
- Chlorine residual
- Hardness as calcium carbonate
- Fluoride
- pH
- Arsenic
- Bacteriological
- Sulfate
- TTHM/HAA5

1.5 Disinfection Contact Time Calculations

The MFRWTP has been designed to treat groundwater to remove iron and manganese. As a groundwater source of supply, the MFRWTP is not required to provide 4-log virus inactivation. However, the City wishes to conduct compliance monitoring as described in the Groundwater Rule to ensure the installed disinfection treatment technology reliably achieves 4-log inactivation or removal of viruses.

Free chlorine is used at the MFRWTP to oxidize iron and manganese and facilitate their removal in greensand filters. Because a free chlorine residual is maintained throughout the treatment process, disinfection credit can be claimed.

A summary of the CT calculations is presented in Table C. The required CT of 6 mg/L-min corresponding to 4-log virus inactivation is provided at the MFRWTP by maintaining a free chlorine residual in the raw water pipe, through the filter pressure vessels, and in the filtered/treated water pipe. The total CT provided at the initial (17.4 mgd) and ultimate (25.3 mgd) plant capacities is 7.3 and 6.4 mg/L-min, respectively. These CT values are 22 percent and 7 percent above the required value 6 mg/L-min for the initial and ultimate plant capacities, respectively.

Table C: Contact Time Calculation Summary

	Contact Time (min)	CT (mg/L-min)[(a)]
Initial Capacity (17.3 mgd)		
Raw Water Pipe	1.19	1.2
Treated Water Pipe	1.17	1.2
Filter Vessels	4.99	5.0
	Total	**7.3**
Ultimate Capacity (25.3 mgd)		
Raw Water Pipe	0.81	0.8
Treated Water Pipe	0.81	0.8
Filter Vessels	4.79	4.8
	Total	**6.4**

Note:

(a) Free chlorine residual = 1 mg/L at compliance point (see Figure B-1 in Appendix B).

The detailed CT calculations are presented in Technical Memorandum No. 8 (revised July 2012) in Appendix B.

1.6 Corrosion Control Plan

The purpose of this section is to present the corrosion control strategy so the City will remain in compliance with the Lead and Copper Rule (LCR) once the City changes its source of drinking water supply from the Cowlitz River to groundwater and the MFRWTP is in operation.

The LCR established Action Levels (ALs) of 0.015 mg/L (15 µg/L) for lead and 1.3 mg/L for copper, based upon the 90^{th} percentile level of targeted tap water samples. As a medium-sized system, the LCR requires the City to comply with the ALs, but not to reduce lead and copper to the lowest levels feasible. The LCR requires lead and copper samples to be first-draw, collected from consumers' kitchen or bathroom cold water tap following a 6-hour period in which the tap had not been used. The 90^{th} percentile values of the data collected are calculated for compliance purposes. Standard sampling for a medium-sized system is 60 samples every 6 months. If lead and copper values are sufficiently low, the City can quality for reduced sampling.

Chemical pH adjustment with caustic soda is the most common approach in the Pacific Northwest for corrosion control treatment of groundwater. Maintaining a target pH of 7.5, using caustic soda, has a successful track record for LCR compliance in Western Washington. Therefore, maintaining a pH target of at least 7.5 is appropriate. Matching the pH in the system was also considered important to avoid unnecessary pH deviations within the system and to maintain the stability of passivating scales, to the extent possible. Therefore, a pH target of 7.6 in the finished water is recommended. As a contingency plan, the finished water goal will be raised to 7.8, to address unexpectedly high levels of copper (or lead) during LCR compliance sampling following the transition to the groundwater supply. It is recommended that the LCR sampling be conducted several months after the transition to the MFRWTP treated water to allow the system to equilibrate prior to conducting LCR sampling.

Spreadsheet water quality modeling was performed to determine the value of several water quality parameters and corrosion indices, after pH adjustment of the finished water to a pH of 7.6. The following findings are based upon this analysis of the calculated index values:

- Sodium hydroxide addition is anticipated to result in a water quality within the preferred range for most of the calculated water quality indices. One exception is the calcium carbonate precipitation potential which is lower than preferred. This is not expected to be problematic because it remains in a similar range as the existing water in the distribution system and dissolution of an existing calcium carbonate scale is not anticipated.

- The finished water quality for the MFRWTP is:

    - Less aggressive with respect to calcium carbonate scale than the Cowlitz River finished water.

    - Not expected to cause excessive scale formation in hot water heaters.

    - Less aggressive to concrete and asbestos cement pipe compared to the Cowlitz River finished water.

    - Exhibits much less tendency for steel corrosion and removal of zinc from brass compared to the Cowlitz River finished water.

More details concerning the corrosion control plan are presented in Technical Memorandum No. 6 (revised 6 July 2012) in Appendix C.

Section 2: Wellfield Information

2.1.1 Vicinity Map

The City's proposed Mint Farm Wellfield is located within the Mint Farm Industrial Park on the western side of Longview, Washington, within Section 31 of Township 8N, Range 2W (see Figure 1). The proposed wellfield site is located at 1155 Weber Avenue on Cowlitz County Tax Parcel Number 101930306. Figure 3 shows the proposed wellfield site, surrounding vicinity, and monitoring well locations.

2.1.2 Well Design, Construction, and Testing

The first production well (PW-1) was drilled as part of the hydrogeologic characterization in 2009. In 2011, three additional test production wells (PW-2, PW-3, and PW-4) were installed and tested at the proposed Mint Farm Wellfield. The three additional wells were constructed and tested in a similar manner as PW-1, except for an extended pump test conducted for PW-1. Because drilling and construction methods were the same as those employed in 2009 for production well PW-1, well design, construction, and testing tasks for the new wells are only briefly summarized here.

Part 2A of the City's Mint Farm Regional Water Treatment Plant Preliminary Design Report (PDR) (Kennedy/Jenks Consultants 2010, Appendix A), which thoroughly documents earlier work related to the installation and testing of well PW-1, can be consulted for additional information about similar activities performed for wells PW-2, PW-3, and PW-4.

The four well boreholes were drilled using the cable-tool drilling method with equipment operated by Boart Longyear under contract to the City. The wells were drilled, constructed, and tested in accordance with the provisions of WAC 173-160, Minimum Standards for Construction and Maintenance of Wells. A neat cement grout seal was installed between the 30-inch temporary casing and the 24-inch casing, and extends 150 feet bgs.

The Water Well Report and record drawings showing the final completion details of each production well are included in their respective sections of this report. The total depth of the wells ranges from 352 to 385 feet bgs. The wells are screened in the coarse sand and gravel deposits of the deep confined aquifer. An 18-inch-diameter casing riser extends into the 24-inch upper well casing 35 feet, with a 5-foot section of relief screen (0.040-inch slot size) positioned within the blank riser section. The screen assembly consists of 18-inch-diameter Type 304 stainless-steel wire-wrapped well screen with a 0.070-inch slot size, with a filter pack consisting of 6x9 Colorado Silica Sand (No. 6 SRI Sand) installed in the annular space around the screen (this filter pack material also extends up into the 24-inch production casing to within 5 feet of the top of the well screen assembly). PW-1 and PW-2 also include a segment of 0.040-inch slot size screen Type 304 stainless-steel wire-wrapped well screen and the filter pack of 8x20 Colorado silica sand.

PW-1 was developed by surging, bailing, and pumping with an air lift pump for several days. Final well development was conducted using pumping rates up to approximately 4,600 gpm. A diesel-engine powered vertical-turbine test pump was installed to complete final well development and perform step-rate and constant-rate pumping tests. A step-rate pumping test was conducted for approximately 60 minutes at four rates ranging from 3,000 to 4,600 gpm in increments of approximately 500 gpm. A constant-rate pumping test was conducted in production well PW-1. At the start of the test, the planned duration was 30 days, with an option to extend to 60 days if observed conditions indicated additional benefits could be derived from the longer-duration test. After 36 days, based on the results of the constant-rate pumping test, it was determined that no further benefit would be obtained by continuing the pump test. Water quality testing of PW-1, in conformance with DOH drinking water requirements, was conducted at the conclusion of the 36-day pump test.

After wells PW-2, PW-3, and PW-4 were constructed, initial well development was performed by surging and periodic pumping at approximately 200 to 250 gpm using a trash pump for approximately 2 days. A diesel-engine-powered vertical-turbine test pump was installed on each well to complete final well development and perform the constant-rate pumping test at rates up to 4,500 gpm. The discharge rate was controlled primarily with a gate valve installed within the pump discharge pipe, with secondary control provided by regulating the engine operating speed. The development water was directed to the onsite storm sewer system, with eventual discharge to CDID Ditch No. 5 located parallel and adjacent to Industrial Way.

During final well development, entrained sand content was measured periodically using a Rossum-type sand tester to assess the adequacy of development activities. Initial sand concentrations measured during final development were on the order of 1 part per million (ppm) or less; final sand concentrations measured at the end of each development pumping cycle ranged from only a fraction of 1 part per million (ppm) to no measurable sand.

The extensive hydrogeologic characterization work conducted for the monitoring wells and PW-1 precluded the need for additional sophisticated aquifer test analyses for wells PW-2, PW-3, and PW-4. This effort included aquifer recharge and discharge areas being identified, and representative aquifer parameters (e.g., transmissivity and storability) derived on the basis of the long-term (36-day) pumping test for PW-1. DOH concurred with this determination and approved a 12-hour pump test for the remaining three wells.

A constant-rate pumping test was performed at each well for 12 hours at the average discharge rate shown in Table D. During the constant-rate pumping test, the pumping water levels were measured using both a manual water-level meter and a data-logging pressure transducer.

The maximum measured drawdown in each well at the conclusion of the 12-hour constant-rate pumping tests and the pump tests is also shown in Table D. Also shown in the table are estimated aquifer transmissivity values calculated using the specific capacities for each well obtained from the pump test measurements. The transmissivity and specific capacity values calculated for the deep aquifer near production wells PW-2 through PW-4 compare very favorably with previously-derived aquifer parameter values.

Table D: Well-Specific Capacity and Estimated Transmissivity

Well	Average Discharge (gpm) (+/- 5%)	Drawdown at End of 12-hour Test (feet)	Drawdown at End of Pump Test (feet)	Specific Capacity (gpm/ft)	Estimated Transmissivity (T) (gpd/ft)
PW-1 (2009 36 day pump test)	3,918	3.1	3.3[(a)]	1,187	3.3-4.5
PW-2 (2011 12 hr. pump test)	3,982	2.2	2.2	1,810	3.62
PW-3 (2011 12 hr. pump test)	3,987	1.9	1.9	2,100	4.2
PW-4 (2011 12 hr. pump test)	3,950	1.7	1.7	2,300	4.6

Note:

(a) Average sustained drawdown during the 36-day pump test.

During constant-rate pumping tests, groundwater levels were also measured using data loggers installed in nearby monitoring wells DW-9, SW-9, and an adjacent production well. After correcting for Columbia River tidal influences on deep aquifer groundwater levels, calculated drawdown at DW-9 during the 36-day test of PW-1 ranged from 0.21 to 0.46 foot, with an average drawdown of 0.33 foot used for analytical purposes. There was no discernible response in the shallow monitoring well SW-9, adjacent to DW-9, during the testing of PW-1. There was no discernible response to pumping of PW-2, PW-3, or PW-4 in either DW-9 or SW-9 observation wells, or the adjacent production wells. The wells recovered from each of the pump tests within minutes. There was no measureable sand content in water discharged from any of the production wells during the 12-hour pumping test.

Field observations and yield test results for newly installed production wells PW-2, PW-3, and PW-4 are consistent with the findings of similar work conducted for PW-1 in 2009. The well logs for each well show similar geologic conditions, and the transmissivity and specific capacity values are similar, summarized in Table D.

2.1.3 Water Rights / Self-Assessment

Water rights for the Mint Farm Wellfield project were obtained from Ecology on 22 November 2010. The water right permit (Number G2-30521) was issued to the City for the combined service areas of the City and Cowlitz PUD. The Cowlitz PUD transferred ownership of its water system and responsibility for all existing water-related agreements and permits to BHWSD effective 1 January 2011. The groundwater right permit allows a maximum instantaneous withdrawal of 28,250 gpm and a non-additive annual withdrawal of 13,500 acre-feet per year (ac-ft/yr). The City intends to maintain their surface water rights on the Cowlitz River and, together with the groundwater right, the combined annual withdrawal cannot exceed 14,629 ac-ft/yr.

Exhibit 2-1 is the Water Rights Self-Assessment – Project Report Form. The new facilities are designed to meet anticipated maximum day demands with one well and one pressure filter out of service. The maximum instantaneous flow rate on the existing status self-assessment form is the maximum daily demand from 2010 (9.18 mgd). The 20-year forecasted flow (11.85 mgd) is from the 2012 Water System Plan.

2.1.4 Site Plan

The City owns the approximately 10-acre site for the wellfield, treatment facilities, and operations office. A copy of the Statutory Warranty Deed is provided at the end of this section (Exhibit 2-2). The wells, which are 200 feet apart, are located on the southwestern side of the parcel. Each well has a 100-foot radius sanitary control area that will be kept free of encroachments except for the well pump house facilities, discharge pipe, and a gravel access road. All chemical storage, treatment, backwash facilities, stormwater basins, operations center, and treatment-related access roads are located at least 100 feet from the nearest well, as shown on the Site Plan (Figure 7). The wellfield site piping plan is shown on Figure 8.

The following utilities are required at the facility: sanitary sewer, potable water, stormwater management, electrical power, telephone, and communications. Natural gas service will not be provided to the site but is available in the area.

All development activity within the City is subject to the requirements of the City Stormwater Ordinance (LMC 17.100), which presents the minimum design standards for erosion and stormwater control. A stormwater swale situated between the wellfield and treatment facilities will address the site water quality requirements.

For site security, a chain link fence will surround the entire site, with keypad automatic locking gates at the access roads to Weber Avenue.

Each of the four well sites was inspected by Cowlitz County Health Department staff and found to be satisfactory. A copy of the inspection report and approval letter can be found in the following sections for each well.

Flow from each well will be metered as well as the total water entering the treatment process to adjust chemical dosage as shown on Construction Drawing M304 (FE300) in Appendix D. Individual magnetic meters will also measure the output of each filter as shown on Construction Drawing M306 (FE301), also in Appendix D. All meters are connected to the facility's SCADA system and will continuously transmit data for process control and records retention.

Raw water sampling is provided for each well as shown on Construction Drawing M201 ("SA"on the pump control valve tee). Additional sampling points are available throughout the treatment plant.

Contract documents for the water treatment facilities include specifications and drawings for the well pumps, meters, and raw and treated water sampling taps. Contract specifications, contractor submittals, and manufacturer's literature for the pumps and meters are included in Appendix D.

2.1.5 Wellhead Protection

WAC 246-290-135 (3) requires water systems using groundwater to develop and implement a wellhead protection program. The City's WHPP has been completed and was approved by the City Council on 9 February 2012. Additionally, the City approved Ordinance 3209 Water Supply Protection on 28 June 2012.

The 6-month, 1-year, 5-year, and 10-year time-of-travel zones were developed in a three-dimensional numerical groundwater model using the USGS Code MODFLOW2000. A 12 mgd ADD for the wellfield was used in the model which represents average daily demand as projected in the 2005 Water System Plan for 2059. Current forecast suggest an ADD of about 8 mgd for 2032 based on recent reduced system demands. As a result, the analysis is quite conservative allowing for an unexpected industrial or commercial demand, or higher than forecasted growth. The groundwater flow patterns were calculated using MODPATH, a particle tracking program that uses the hydraulic gradient, hydraulic conductivity, and porosity. The model results indicate that travel times for water from the Columbia River to the Mint Farm Wellfield range from approximately 2 years to 10 years within the Wellhead Protection Area (WHPA), as shown on Figure 6. The WHPA was based on the MODFLOW Model and includes a reasonable buffer zone. The buffer zone was established to adopt a conservative approach to wellhead protection and to establish boundaries that are clearly identifiable in the field. City boundaries, existing roads, and parcel lines were also considered. The WHPA boundaries are also shown on Figure 6.

The three-part ESA, presented in detail in the *City of Longview Mint Farm Regional Water Treatment Plant Preliminary Design Report* (Kennedy/Jenks Consultants 2010), initiated the identification of a potential contaminant inventory and its potential adverse impact on groundwater quality at the proposed wellfield. No complete pathways between potentially contaminating activities in the Mint Farm area and the deep groundwater aquifer were identified by the The MODFLOW model. The model, which tested three worst-case scenarios at identified potentially contaminating activities, also indicates that no contamination from any potential source is expected to reach the Mint Farm Wellfield within a 30-year timeframe. The inventory was then expanded to include the entire wellhead protection area (including buffer zone). The potential contaminant inventory is listed in Table E and shown on Figure 9.

Notification of owners / operators of known or potential sources of groundwater contamination and of regulatory agencies and local governments of the boundaries and significance of the WHPA will be completed prior to plant start-up. A contingency plan in the event of well contamination and a discussion of coordination with local emergency incident responders will be presented in the complete WHPP section of the 2012 Water System Plan update. Susceptibility assessments have been completed for each well and are included in the following sections along with the other well-specific information.

2.1.6 Construction Completion Report

A Construction Completion Report and updated Water Facilities Inventory will be submitted upon completion of the wellfield and treatment facilities, as required by WAC 246-290 120.

Table E: List of Potential Sources of Contamination Potential

Company/Business	Site Name	Map Location	Latitude/Longitude	Time of Travel Zone
Moeller Land/Cattle Co.	Flex Foam Facility	1	46.1375/122.98583	6-Month
Bonneville Power Administration	Longview Substation	2	46.13716/-122.98786	6-Month
Mint Farm Energy Ctr, LLC	Energy Plant	3	48.14028/122.985	6-Month
Weyerhaeuser	Mint Farm	4	46 8 54.83/122 58 43.62	6-month
Weyerhaeuser	HG Chlor Alkali	5	46.13171/-122.9785	6-Month
Washington Way Market	Washington Way Market	6	46.1315/-122.97555	6-Month
Weyerhaeuser	Plywood Mill	7	46.13172/-122.9785	6-Month
Columbia/Cowlitz Railway	Rail Spur	8	N/A	6-Month
Woodinville Lumber, Inc.	Tri County Truss	9	46 8 30.38/122 58 59.29	6-Month
Solvay Interox	Solvay Interox Facility	10	46 8 18.39/122 58 50.35	6-Month
HASA (J Huber)	HASA (J Huber)	11	46 8 6.70/122 58 49.03	6-Month
Millennium Bulk Terminals	Millennium Bulk Terminals - Longview	12	46 8 29/122 59 46	5-Year
Millers Market	Millers Market	13	46.13252/-122.96597	5-Year
Unknown	Unknown Diesel Spill	14	46 9 2.63/123 1 19.23	Buffer area
Longview Auto Wrecking	Longview Auto Wrecking	15	46 8 56.501/122 59 15	Buffer area
Fred Meyer	Fred Meyer Fuel Stop	16	46 08 52.43/-122 57 48.31	Buffer area
Safeway	Safeway Fuel Station	17	46 8 52.71 / 122 57 40.93	Buffer area
Rio West Restaurant	Rio West Restaurant	18	46 8 49.898/122 57 40.702	Buffer area
McCall Trucking	McCall Trucking	19	46.14846/-123.00753	Buffer area
Port of Longview	Port of Longview	20	46 6 31.63/122 56 47.33	Buffer area
US EPA Dorothy Ave Mercury Spill	US EPA Dorothy Ave Mercury Spill	21	46 8 44.84/122 58 13.99	Buffer area
Longview School District	Longview School District 122	22	46.15274/-122.98525	Buffer area
Shell/Texaco Station	Shell/Texaco Station	23	46 8 51/122 57 52	Buffer area
Robert Radakovich Sr/ Port of Longview	Mt. Solo Landfill	24	46 8 59.04/123 00 51.68	Buffer area
Toyocom	Toyocom Devices of America	25	46 8 52.07/122 59 11.81	Buffer area
Ocean Beach Chevron	Ocean Beach Chevron	26	46 8 52/122 57 46	Buffer area
Teevin Brothers	Teevin Brothers	27	46.097391/122.956932	Buffer area
US Gypsum Co	US Gypsum Co	28	46 06 13.52/122 58 20.80	Buffer area
Rainer Shell	Sheel Gas Station	29	46.094352/122.963032	Buffer area

Section 3: Production Well No. 1 (PW-1)

This section describes the specific characteristics of Production Well PW-1, which has an Ecology Well Identification Tag Number of BAM420. The following information is presented as exhibits for this section:

- Cowlitz County Health Department Well Site Approval Letter and Inspection Form
- Ecology Water Well Report
- Record Drawings of PW-1
- DOH Ground Water Contamination Susceptibility Assessment Survey Form
- Water Quality Analysis results.

Various construction drawings, specifications and contractor submittals are included in Appendix D of this report.

3.1 Well Site Inspection

The well site inspection was conducted on 28 July 2009 by Mr. Jesse Smith of the Cowlitz County Health Department. He found the site for the proposed well to be satisfactory. A copy of the well site inspection form and the letter from Cowlitz County Health Department is provided as an exhibit.

The well site has been graded to eliminate standing water and only the well, pump house, transmission main, and gravel access road are within the 100-foot sanitary control area.

3.2 Well Information

The well was drilled by Boart Longyear, a Washington State licensed water well driller, using the cable-tool drilling method. The 24-inch well was drilled, constructed, and tested in accordance with the provisions of WAC 173-160, Minimum Standards for Construction and Maintenance of Wells. PW-1 was completed on 20 November 2009 to a depth of 375 feet with 18-inch stainless steel screens installed between 230 to 285 feet and 299.2 to 370.8 feet. The well was gravel packed from 195 to 375 feet.

A cement bentonite grout surface seal was installed between a 30-inch temporary casing and the 24-inch well casing to a depth of 150 feet. A copy of the Washington State Water Well Report and a record drawing of the well are included.

PW-1 was developed by surging, bailing, and pumping with an air lift pump for several days. Final well development was conducted using pumping rates up to approximately 4,600 gpm. A step-rate pumping test was conducted for approximately 60 minutes at four rates ranging from 3,000 to 4,600 gpm in increments of approximately 500 gpm. A constant-rate pumping test was conducted in production well PW-1. At the start of the test, the planned duration was 30 days, with an option to extend to 60 days if observed conditions indicated additional benefits could be derived from the longer-duration test. After 36 days, based on the results of the constant-rate pumping test, it was determined that no further benefit would be obtained by continuing the pump test. The average sustained drawdown for the well was 3.3 feet with recovery rate of just a few minutes. Drawdown at test well DW-9, located approximately 50 feet south of PW-1 showed an average drawdown of 0.33 feet after allowing for tidal influences on the deep aquifer groundwater levels.

Based on the results of 36 day pump test, aquifer Transmissivity was estimated at 3.3 to 4.5 gpd/ft and the Specific Capacity of the well at 1,187 gpm/ft.

3.3 Pump, Meter, and Raw Water Sampling Tap Information

The pumping and related equipment for PW-1 is shown on Construction Drawing M201 in Appendix D, and is the identical to the facilities in the other pump houses. The water is transported to the treatment plant through raw water transmission mains located in the access road as shown on Construction Drawing C110 also in Appendix D.

The well has been equipped with a 400 horsepower Floway pump (Model number 16DKH) capable of pumping 4,000 gpm at 315 feet head and at an approximately 84 percent efficiency. The pump specifications, contractor submittals, and manufacturer's literature for the pump are included in Appendix D.

Flow from the well will be metered by Cla-Valve metering valve (Model Number 663-01) with electronic controller valve as shown on Construction Drawing M201 in Appendix D. The metering valve is connected to the facility's SCADA system and will continuously transmit data for facility control and records retention. The metering valve specifications and manufacturer's literature is included in Appendix D.

Raw water sampling is provided as shown on Construction Drawing M201 ("SA"on the pump control valve tee). Construction Drawing P504, Process and Instrumentation Diagram Lab Sampling and Analysis Systems further illustrate the additional sampling points available for start-up and plant optimization.

3.4 Groundwater Contamination Susceptibility Assessment Survey Form

The DOH Susceptibility Assessment Form for PW-1 has been completed and is included in this section as Exhibit 3-1.

3.5 Water Quality

Following the 36-day pump test, but prior to well disinfection, water quality samples were collected and analyzed for the following analytes:

- Inorganic Chemicals
- Volatile Organic Compounds (VOCs) (EPA Method 524.2)
- Synthetic Organic Chemicals (EPA Test Methods 504.1, 515.4, 525.2/508.1, 531.1 547, 548.1, 549.2)

- Dioxin (EPA Method 1613)
- Radionuclides
- Bacteriological Analysis (reported on IOC form).

Total coliform was detected in the first raw water sample. Since the sample was collected prior to disinfecting the well, the positive results were not surprising. The well was disinfected after the collection of the initial water quality samples. The well and pumping equipment will be disinfected again as part of the pre-startup plan for the treatment plant. Once the well is flushed following the second disinfection, a second bacteriological sample will be collected. The chlorination system for the water treatment plant is designed to provide a minimum CT of 6 mg/L-minutes throughout the range of anticipated flows in order to comply with the compliance monitoring section of the groundwater rule.

Iron and manganese exceed the secondary MCL, but will be removed by the greensand filters in the treatment plant. No other analyte exceeded a MCL or was of a level of concern.

3.5.1 Specific Action Plan

Collect raw water bacteriological sample following disinfection of the well and pumping equipment as part of the startup plan. The results will be submitted to DOH on proper forms.

Section 4: Section 4: Production Well No. 2 (PW-2)

This section will describe the specific characteristics of Production Well PW-2, which has an Ecology Well Identification Tag Number of BHF855. The following information is presented as exhibits for this section:

- Cowlitz County Health Department Well Site Approval Letter and Inspection Form
- Ecology Water Well Report
- Record Drawings of PW-2
- DOH Ground Water Contamination Susceptibility Assessment Survey Form
- Water Quality Analysis results.

Various construction drawings, specifications, and contractor submittals are included in Appendix D of this report.

4.1 Well Site Inspection

The well site inspection was conducted on 20 April 2010 by Mr. Jesse Smith of the Cowlitz County Health Department. He found the site for the proposed well to be satisfactory with the condition that the well site be leveled to prevent the accumulation of standing water in the sanitary control area. A copy of the well site inspection form and the letter from Cowlitz County Health Department is provided as an exhibit.

The well site has been graded to eliminate standing water and only the well, pump house, transmission main, and gravel access road are within the 100-foot sanitary control area.

4.2 Well Information

The well was drilled by Boart Longyear, a Washington State licensed water well driller, using the cable-tool drilling method. The 24-inch well was drilled, constructed, and tested in accordance with the provisions of WAC 173-160, Minimum Standards for Construction and Maintenance of Wells. PW-2 was completed to a depth of 378 feet with an 18-inch stainless steel screen installed between 228 and 370 feet. The well was gravel packed from 193 to 375.5 feet.

A cement grout surface seal was installed between a 30-inch temporary casing and three 24-inch well casings to a depth of 150 feet. A copy of the Washington State Water Well Report and a record drawing of the well are included.

PW-2 was developed by surging and periodic pumping at approximately 200 to 250 gpm for two days. Final well development was conducted using pumping rates ranging from approximately 500 to 4,500 gpm. During that time, the pump was repeatedly cycled over a period of several hours.

A 12-hour constant-rate pumping test was conducted in production well PW-2 at an average rate of 3,982 gpm. The maximum measured drawdown in PW-2 was approximately 2.2 feet at the conclusion of the test with immediate recovery at the conclusion of the pump test. During the constant-rate pump test, groundwater levels were also measured in PW-1, DW-9, and SW-9. After correcting for Columbia River tidal influences on deep aquifer groundwater levels, there was no discernible response to pumping PW-2 in any of the three observation wells. Based on the results of 12-hour constant-rate pump test, aquifer transmissivity was estimated at 3.62 gpd/ft and the specific capacity of the well calculated at 1,810 gpm/ft. The transmissivity values calculated for PW-2 compare favorably with the previously derived aquifer parameter values. The extensive hydrogeologic characterization work previously conducted precluded the need for prolonged a pumping and additional aquifer tests.

4.3 Pump, Meter, and Raw Water Sampling Tap Information

The pumping and related equipment for PW-2 is shown on Construction Drawing M201 in Appendix D, and is the identical to the facilities in the other pump houses. The water is transported to the treatment plant through raw water transmission mains located in the access road as shown on Construction Drawing C110 also in Appendix D.

The well has been equipped with a 400 horsepower Floway pump (Model number 16DKH) capable of pumping 4,000 gpm at 315 feet head and at an approximate 84 percent efficiency. The pump specifications, contractor submittals, and manufacturer's literature for the pump is included in Appendix D.

Flow from the well will be metered by Cla-Valve metering valve (Model Number 663-01) with electronic controller valve as shown on Construction Drawing M201 in Appendix D. The metering valve is connected to the facility's SCADA system and will continuously transmit data for facility control and records retention. The metering valve specifications and manufacturer's literature are included in Appendix D.

Raw water sampling is provided as shown on Construction Drawing M201 ("SA"on the pump control valve tee). Construction Drawing P504, Process and Instrumentation Diagram Lab Sampling and Analysis Systems further illustrate the additional sampling points available for start-up and plant optimization.

4.4 Groundwater Contamination Susceptibility Assessment Survey Form

The DOH Susceptibility Assessment Form for PW-2 has been completed and is included in this section as Exhibit 4-1.

4.5 Water Quality

During the last several hours of the 12-hour pump test, but prior to well disinfection, water quality samples were collected and analyzed for the following analytes:

- Inorganic Chemicals
- VOCs (EPA Method 524.2)

- Synthetic Organic Chemicals (EPA Test Methods 504.1, 515.4, 525.2/508.1, 531.1, 547, 548.1, 549.2)
- Dioxin (EPA Method 1613)
- Radionuclides
- Bacteriological Analysis (reported on IOC form).

Total coliform was detected in the first raw water sample. Since the sample was collected prior to disinfecting the well, the positive results were not surprising. The well was disinfected after the collection of the initial water quality samples. The well and pumping equipment will be disinfected again as part of the pre-startup plan for the treatment plant. Once the well is flushed following the second disinfection, a second bacteriological sample will be collected. The chlorination system for the water treatment plant is designed to provide a minimum CT of 6 mg/L-minutes throughout the range of anticipated flows in order to comply with the compliance monitoring section of the groundwater rule.

Iron and manganese exceed the secondary MCL, but will be removed by the greensand filters in the treatment plant. No other analyte exceeded a MCL, or was of a level of concern.

4.5.1 Specific Action Plan

Collect raw water bacteriological sample following disinfection of the well and pumping equipment as part of the startup plan. The results will be submitted to DOH on proper forms.

Section 5: Section 5: Production Well No. 3 (PW-3)

This Section will describe the specific characteristics of Production Well PW-3, which has an Ecology Well Identification Tag Number of BHF856. The following information is presented as exhibits for this section:

- Cowlitz County Health Department Well Site Approval Letter and Inspection Form
- Ecology Water Well Report
- Record Drawings of PW-3
- DOH Ground Water Contamination Susceptibility Assessment Survey Form
- Water Quality Analysis results.

Various construction drawings, specifications and contractor submittals are included in Appendix D.

5.1 Well Site Inspection

The well site inspection was conducted on 20 April 2010 by Mr. Jesse Smith of the Cowlitz County Health Department. He found the site for the proposed well to be satisfactory with the condition that the well site be leveled to prevent the accumulation of standing water in the sanitary control area. A copy of the well site inspection form and the letter from Cowlitz County Health Department is provided as an exhibit.

The well site has been graded to eliminate standing water and only the well, pump house, transmission main, and gravel access road are within the 100-foot sanitary control area.

5.2 Well Information

The well was drilled by Boart Longyear, a Washington State licensed water well driller, using the cable-tool drilling method. The 24-inch well was drilled, constructed, and tested in accordance with the provisions of WAC 173-160, Minimum Standards for Construction and Maintenance of Wells. PW-3 was completed to a depth of 352 feet with an 18-inch stainless steel screen installed between 235 and 345 feet. The well was gravel packed from 201 to 350 feet.

A cement grout surface seal was installed between a 30-inch temporary casing and three 24-inch well casings to a depth of 150 feet. A copy of the Washington State Water Well Report and a record drawing of the well are included.

PW-3 was developed by surging and periodic pumping at approximately 200 to 250 gpm for two days. Final well development was conducted using pumping rates ranging from approximately 500 to 4,500 gpm. During that time, the pump was repeatedly cycled over a period of several hours.

A 12-hour constant-rate pumping test was conducted in production well PW-3 at an average rate of 3,987 gpm. The maximum measured drawdown in PW-3 was approximately 1.9 feet at the conclusion of the test with immediate recovery at the conclusion of the pump test. During the constant-rate pump test, groundwater levels were also measured in PW-2 (about 200 feet away), DW-9, and SW-9 (about 400 feet away). After correcting for Columbia River tidal influences on deep aquifer groundwater levels, there was no discernible response to pumping PW-3 in any of the three observation wells. Based on the results of 12-hour constant-rate pump test, aquifer transmissivity was estimated at 4.2 gpd/ft and the specific capacity of the well calculated at 2,100 gpm/ft. The transmissivity values calculated for PW-3 compare favorably with the previously derived aquifer parameter values. The extensive hydrogeologic characterization work previously conducted precluded the need for prolonged a pumping and additional aquifer tests.

5.3 Pump, Meter, and Raw Water Sampling Tap Information

The pumping and related equipment for PW-3 is shown on Construction Drawing M201 in Appendix D, and is the identical to the facilities in the other pump houses. The water is transported to the treatment plant through raw water transmission mains located in the access road as shown on Construction Drawing C110 also in Appendix D.

The well has been equipped with a 400 horsepower Floway pump (Model number 16DKH) capable of pumping 4,000 gpm at 315 feet head and at an approximate 84 percent efficiency. The pump specifications, contractor submittals, and manufacturer's literature for the pump is included in Appendix D.

Flow from the well will be metered by Cla-Valve metering valve (Model Number 663-01) with electronic controller valve as shown on Construction Drawing M201 in Appendix D. The metering valve is connected to the facility's SCADA system and will continuously transmit data for facility control and records retention. The metering valve specifications and manufacturer's literature are included in Appendix D.

Raw water sampling is provided as shown on Construction Drawing M201 ("SA"on the pump control valve tee). Construction Drawing P504, Process and Instrumentation Diagram Lab Sampling and Analysis Systems further illustrate the additional sampling points available for start-up and plant optimization.

5.4 Groundwater Contamination Susceptibility Assessment Survey Form

The DOH Susceptibility Assessment Form for PW-3 has been completed is included in this section as Exhibit 5-1.

5.5 Water Quality

During the last several hours of the 12-hour pump test, but prior to well disinfection, water quality samples were collected and analyzed for the following analytes:

- Inorganic Chemicals

- VOCs (EPA Method 524.2)
- Synthetic Organic Chemicals (EPA Test Methods 504.1, 515.4, 525.2/508.1, 531.1, 547, 548.1, 549.2)
- Dioxin (EPA Method 1613)
- Radionuclides
- Bacteriological Analysis (reported on IOC form).

Total coliform was detected in the first raw water sample. Since the sample was collected prior to disinfecting the well, the positive results were not surprising. The well was disinfected after the collection of the initial water quality samples. The well and pumping equipment will be disinfected again as part of the pre-startup plan for the treatment plant. Once the well is flushed following the second disinfection, a second bacteriological sample will be collected. The chlorination system for the water treatment plant is designed to provide a minimum CT of 6 mg/L-minutes throughout the range of anticipated flows in order to comply with the compliance monitoring section of the groundwater rule.

Iron and manganese exceed the secondary MCL, but will be removed by the greensand filters in the treatment plant. No other analyte exceeded a MCL, or was of a level of concern.

Diquat was detected at 1.6 µg/L, which is above the Method Reporting Level (MRL) of 0.8 µg/L, but much lower than the MCL of 20 µg/L. The detection is believed to be a result of sampling or lab error given that diquat was also detected in the field blank. An additional diquat sample was collected on 23 July 2012 with a non-detect result.

5.5.1 Specific Action Plan

Collect raw water bacteriological sample following disinfection of the well and pumping equipment as part of the startup plan. The results will be submitted to DOH on proper forms.

Section 6: Section 6: Production Well No. 4 (PW-4)

This section will describe the specific characteristics of Production Well PW-4, which has an Ecology Well Identification Tag Number of BHF857. The following information is presented as exhibits for this section:

- Cowlitz County Health Department Well Site Approval Letter and Inspection Form
- Ecology Water Well Report
- Record Drawings of PW-4
- DOH Ground Water Contamination Susceptibility Assessment Survey Form
- Water Quality Analysis results.

Various construction drawings, specifications and contractor submittals are included in Appendix D.

6.1 Well Site Inspection

The well site inspection was conducted on 20 April 2010 by Mr. Jesse Smith of the Cowlitz County Health Department. He found the site for the proposed well to be satisfactory with the condition that the well site be leveled to prevent the accumulation of standing water in the sanitary control area. A copy of the well site inspection form and the letter from Cowlitz County Health Department is provided as an exhibit.

The well site has been graded to eliminate standing water and only the well, pump house, transmission main, and gravel access road are within the 100-foot sanitary control area.

6.2 Well Information

The well was drilled by Boart Longyear, a Washington State licensed water well driller, using the cable-tool drilling method. The 24-inch well was drilled, constructed, and tested in accordance with the provisions of WAC 173-160, Minimum Standards for Construction and Maintenance of Wells. PW-4 was completed to a depth of 352 feet with an 18-inch stainless steel screen installed between 237 and 342 feet. The well was gravel packed from 203 to 347 feet.

A cement grout surface seal was installed between a 30-inch temporary casing and three 24-inch well casings to a depth of 150 feet. A copy of the Washington State Water Well Report and a record drawing of the well are included.

PW-4 was developed by surging and periodic pumping at approximately 200 to 250 gpm for two days. Final well development was conducted using pumping rates ranging from approximately 500 to 4,500 gpm. During that time, the pump was repeatedly cycled over a period of several hours.

A 12-hour constant-rate pumping test was conducted in production well PW4 at an average rate of 3,950 gpm. The maximum measured drawdown in PW-4 was approximately 1.7 feet at the conclusion of the test with immediate recovery at the conclusion of the pump test. During the constant-rate pump test, groundwater levels were also measured in PW-3 (about 200 feet away), DW-9, and SW-9. After correcting for Columbia River tidal influences on deep aquifer groundwater levels, there was no discernible response to pumping PW-4 in any of the three observation wells. Based on the results of 12-hour constant-rate pump test, aquifer transmissivity was estimated at 4.6 gpd/ft and the specific capacity of the well calculated at 2,300 gpm/ft. The transmissivity values calculated for PW-4 compare favorably with the previously derived aquifer parameter values. The extensive hydrogeologic characterization work previously conducted precluded the need for prolonged a pumping and additional aquifer tests.

6.3 Pump, Meter, and Raw Water Sampling Tap Information

The pumping and related equipment for PW-4 is shown on Construction Drawing M201 in Appendix D, and is the identical to the facilities in the other pump houses. The water is transported to the treatment plant through raw water transmission mains located in the access road as shown on Construction Drawing C110 also in Appendix D.

The well has been equipped with a 400 horsepower Floway pump (Model number 16DKH) capable of pumping 4,000 gpm at 315 feet head and at an approximate 84 percent efficiency. The pump specifications, contractor submittals, and manufacturer's literature for the pump is included in Appendix D.

Flow from the well will be metered by Cla-Valve metering valve (Model Number 663-01) with electronic controller valve as shown on Construction Drawing M201 in Appendix D. The metering valve is connected to the facility's SCADA system and will continuously transmit data for facility control and records retention. The metering valve specifications and manufacturer's literature are included in Appendix D.

Raw water sampling is provided as also shown on Construction Drawing M201 ("SA" on the pump control valve tee). Construction Drawing P504, Process and Instrumentation Diagram Lab Sampling and Analysis Systems further illustrate the additional sampling points available for start-up and plant optimization.

6.4 Groundwater Contamination Susceptibility Assessment Survey Form

The DOH Susceptibility Assessment Form has been completed for PW-4 and is included in this section as Exhibit 6-1.

6.5 Water Quality

During the last several hours of the 12-hour pump test, but prior to well disinfection, water quality samples were collected and analyzed for the following analytes:

- Inorganic Chemicals
- VOCs (EPA Method 524.2)

- Synthetic Organic Chemicals (EPA Test Methods 504.1, 515.4, 525.2/508.1, 531.1, 547, 548.1, 549.2)
- Dioxin (EPA Method 1613)
- Radionuclides
- Bacteriological Analysis (reported on IOC form).

The well was disinfected after the collection of the initial water quality samples and will be disinfected again after testing of the pumping equipment. The well and pumping equipment will be disinfected again as part of the pre-startup plan for the treatment plant. Once the well is flushed following the second disinfection, a second bacteriological sample will be collected. The chlorination system for the water treatment plant is designed to provide a minimum CT of 6 mg/L-minutes throughout the range of anticipated flows in order to comply with the compliance monitoring section of the groundwater rule.

Iron and manganese exceed the secondary MCL, but will be removed by the Greensand filters in the treatment plant. No other analyte exceeded a MCL, or was of a level of concern.

6.5.1 Specific Action Plan

Collect raw water bacteriological sample following disinfection of the well and pumping equipment as part of the startup plan. The results will be submitted to DOH on proper forms.