Appendix D
Well Locations

Attachment D-1

Well Spacing Calculations

Well Spacing

- BASED ON AQUIFER TESTING PERFORMED (APPENDIX B) AND THE PROPOSED ZONE OF COLLECTION (UPPER BEDROCK, TO A DEPTH OF APPROXIMATELY 50 FEET); THE MOST RELEVENT DATA COLLECTED IS FROM THE ROSS SUPPLY AREA PUMP TEST.
- TESTING AT ROSS SUPPLY yielded A 0.9' DRAWDOWN AT PUMPING WELL AND 0.5' DRAWDOWN at 125' AWAY (SEE chart 1) AT PU-15
- PUMPING RATE = 6 GPM.
- BASED ON THIS, WELL SPACING PROPOSED AT 100 - 150 FOOT SPACING (DEPENDENT ON LOCATION)

ESTIMATED DRAWDOWN

MILLBROOK LANE AREA

PROPOSE 5 PUMPING WELL'S, 100' APART, ALL PUMPING AT 6 GPM. (FIGURE 1)

well spacing
CSSS
184243.PA.01
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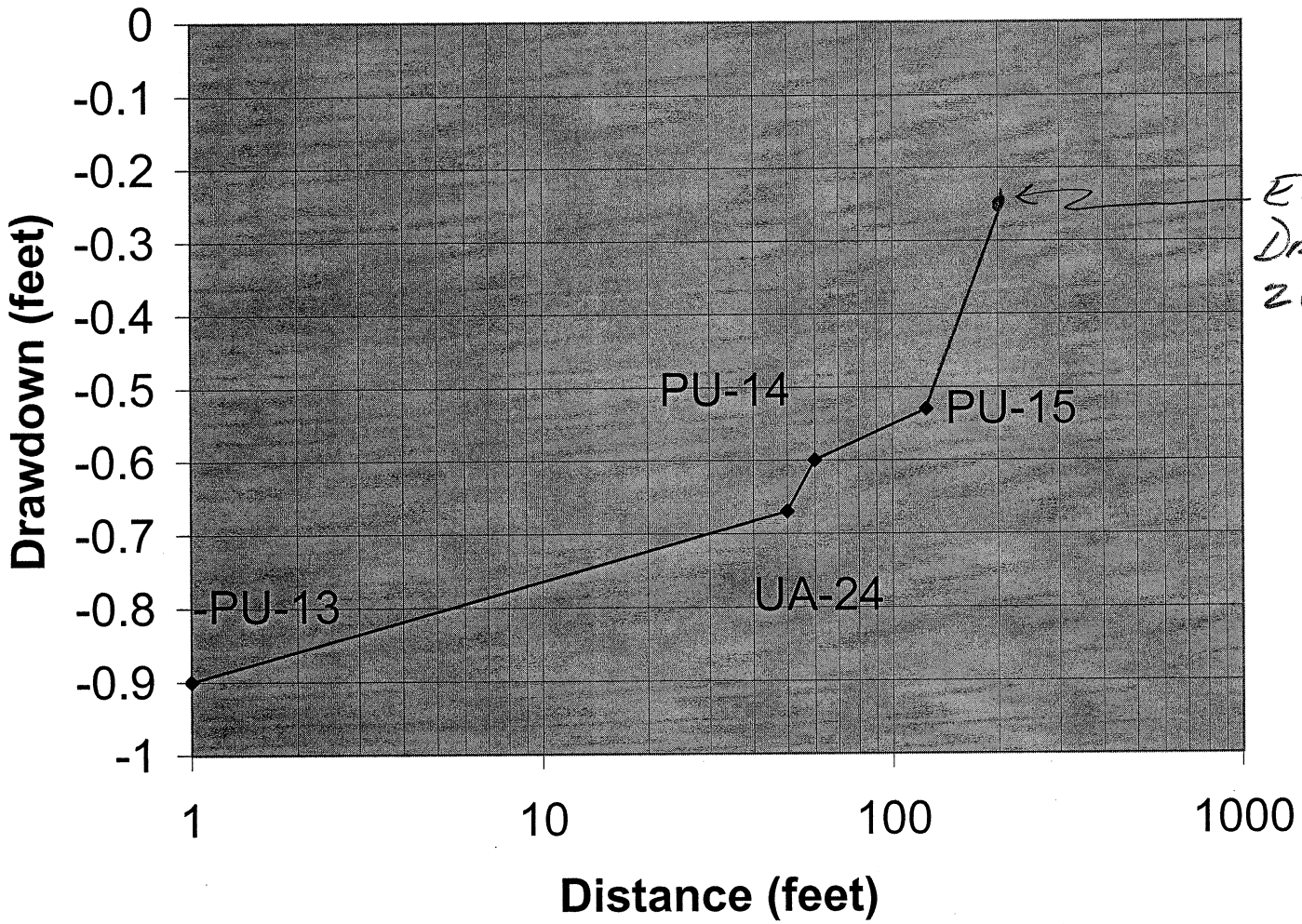
Ross Supply Area Pump Test



ESTIMATED
DRAWDOWN @
200' = 0.25'

Chart 1

Attachment D-2

Groundwater Model

Continental Steel Superfund Site Contract 5—Groundwater: Flow Modeling for Remedial Design

PREPARED FOR: USEPA

PREPARED BY: CH2M HILL

DATE: January 23, 2004

Introduction

This memorandum summarizes the groundwater flow modeling performed for the sitewide groundwater operable unit (OU1) at the Continental Steel Superfund Site (CSSS) in Kokomo, Indiana under Contract 5—Groundwater, Work Assignment (WA) No. 122-RDRD-05BW/Contract No. 68-W6-0025. The Record of Decision (ROD; USEPA and IDEM 1998) issued for the site described the removal and treatment of the shallow groundwater through clusters of extraction wells to be installed at locations within or downgradient from contamination plumes. Groundwater collection systems for the three source areas described in the ROD are as follows:

- **Lagoon Area.** The proposed remedy included a shallow-groundwater trench collection system. The system would be installed to a depth of 45 feet in a U-shape around the downgradient boundary of the VOC plume. The interceptor trench will consist of a 3,000-foot-long outer interceptor trench with an interior east-west bisecting trench. A flow rate of about 35 to 45 gallons per minute (gpm) was expected.
- **Markland Avenue Quarry.** The proposed extraction system included 30 groundwater extraction wells placed along the west and north boundaries of the site to contain the shallow groundwater in the vicinity of the quarry.
- **Main Plant.** The proposed remedy included shallow groundwater collection in a trench collection system installed along the western boundary of the Main Plant, adjacent to Park Avenue and Wildcat Creek. The system would be installed to a depth of about 30 feet and would remove groundwater at a rate of 10 to 15 gpm.

Extracted groundwater would be discharged through underground piping directly to the Kokomo Wastewater Treatment Plant (KWWTP) for treatment and disposal.

The intermediate and lower groundwater aquifers will be addressed through the continued operation of the Martin-Marietta Quarry, invoking a technical impracticability (TI) waiver, and the use of institutional controls in the form of deed and groundwater use restrictions.

After reviewing data collected during the predesign investigation, CH2M HILL proposed to modify the areas targeted for groundwater extraction and treatment. CH2M HILL discussed and received concurrence on the modifications with USEPA and IDEM. This memorandum

discusses the methodology and results of the groundwater flow modeling effort, focused on remediating those target areas.

Proposed Groundwater Collection Systems

Groundwater collection systems and rates are proposed for the following four sites (Figure 1).

Markland Avenue Quarry

The proposed extraction system for the Markland Avenue Quarry includes 1 well, located in the surge rock backfill material of the quarry (after quarry is backfilled and covered) to contain shallow groundwater in the immediate vicinity of the quarry. The well is expected to pump at a rate of 42 gallons per minute (gpm).

East Bank Wildcat Creek, NW of Markland Avenue Quarry

The proposed extraction system for this area is a smaller extraction system consisting of six wells to be installed in a line parallel to the east bank of Wildcat Creek approximately 1,500 feet northwest of the Markland Avenue Quarry. This system is designed to intercept contaminants prior to entering the hydraulically-connected creek. Each well is expected to pump at a rate of 6 gpm, and the entire system would extract 36 gpm.

Millbrook Lane Area

The proposed Millbrook Lane extraction system is a line of five wells to be situated parallel to Millbrook Lane. The purpose of these wells is to extract contaminated groundwater between Wildcat Creek and Millbrook Lane. Each well is expected to pump at a rate of 12 gpm, and the entire system would extract 60 gpm.

West Markland Avenue

The proposed West Markland Avenue extraction system is a line of 4 wells to be situated parallel to Markland Avenue, just west of S. Berkley Road. These wells are designed to extract contaminated groundwater downgradient from the Millbrook Lane Area extraction system. Each well is expected to pump at a rate of 10.4 gpm, and the entire system would extract 42 gpm.

Groundwater Model

The shallow aquifer groundwater flow was modeled using a simple, two-dimensional analytical model to aid in the location and configuration of the extraction systems. The specific objectives of this modeling effort were to:

- Determine the appropriate placement and size of collection system (e.g., potential number of extraction wells or the length of the collection trench) to contain the contaminated groundwater within their current boundaries
- Estimate the quantity of water that will need to be piped to the WWTP

The background information and methods used in achieving these objectives are organized into the following sections of this technical memorandum:

- Site Hydrogeology
- Selection of a Groundwater Flow Model
- Hydraulic Parameters and Hydrologic Features
- Alterations to Initial Model Calibration
- Revised Shallow Groundwater Collection Simulations
- Summary

Site Hydrogeology

The three water-bearing zones or aquifers identified beneath the site include:

- Shallow Water-Bearing Zone or Upper Aquifer
- Intermediate Water-Bearing Zone or Intermediate Aquifer
- Lower Water-Bearing Zone or Lower Aquifer

Based on the groundwater remedies selected in the ROD and the invocation of a TI waiver, the focus of this modeling effort is within the shallow water-bearing zone. The overall groundwater flow and quality conditions at CSSS, including the intermediate and lower water-bearing zones, have been summarized previously (CDM 1997; CH2M HILL 2003).

The shallow water-bearing zone across most of the site consists of 5 to 40 feet of variable fill material and/or native silty clay overlying up to 40 feet of highly fractured and weathered Kokomo Limestone. The water table surface (Figure 2) generally follows surface topographic features, with water flowing from the topographic highs or mounds to the creeks (with a general westward trend) under gradients ranging from 0.002 ft/ft in the central part of the site to 0.028 ft/ft west of the Lagoon Area (CH2M HILL 2003). The shallow aquifer wells tend to be the most prolific groundwater producers of the three hydrostratigraphic zones, with estimated discharge rates up to more than 20 gpm. Although high hydraulic conductivities are observed in the shallow water-bearing zone (e.g., more than 100 feet per day north of the Main Plant Area), hydraulic conductivities vary significantly with location (e.g., 5 feet per day at the Markland Quarry; CH2M HILL 2002). The variability in hydraulic conductivities observed in monitoring wells screened within a single aquifer depend upon such factors as (1) whether wells intersect a water-bearing fracture, (2) whether wells intersect water-bearing bedding plane fractures, and (3) how well the intersected fracture system is developed.

Selection of Groundwater Flow Model

The groundwater flow model WinFlow was the program selected to perform the modeling because it has been used successfully in previous CSSS groundwater simulations. Consistent with the intent of the modeling effort, WinFlow simulates unconfined aquifers in two dimensions under steady-state conditions and also has particle-tracking capabilities. It can simulate the effects of uniform recharge, streams, circular ponds (i.e., quarry and lagoon), and extraction wells under a uniform regional gradient (Environmental Simulations 1995).

WinFlow employs the following simplifying assumptions:

- Groundwater flow is horizontal and occurs in an infinite aquifer.

- Aquifer hydraulic conductivity is isotropic and homogeneous.
- The base of the aquifer is horizontal and fixed at a given elevation.
- In the steady-state models, the top of the aquifer is also horizontal and fixed at a given elevation. Unconfined conditions are, however, simulated when the hydraulic head is below the top of the aquifer.
- The reference head in the steady-state model is constant throughout all calculations. It is analogous to a constant head boundary condition in a numerical model.
- All pumping rates, linesink fluxes, pond recharge, and elliptical recharge rates are constant through time.
- Wells fully penetrate the aquifer. Wells are assumed to be perfectly efficient and linesinks are in perfect hydraulic communication with the aquifer.
- Particle traces and streamlines are two-dimensional.

In general, the model assumptions relating to flow in the shallow water-bearing zone are a reasonable representation of actual conditions, with the exception of the nature of hydraulic conductivity. As noted, hydraulic conductivity varies across the site and depends upon the nature of fracturing at a given location (i.e., it is not isotropic and homogenous). The variable nature of hydraulic conductivity should have a minor impact on system comparisons (i.e., trench versus wells) and the system discharge estimates because these evaluations consider the total system and not point locations. Thus, while actual hydraulic conductivity may vary from point to point (well to well), the average across the system can reasonably be represented by the modeled value.

Hydraulic Parameters and Hydrologic Features

Groundwater collection from the shallow water-bearing zone (i.e., upper aquifer; CH2M HILL 2003) was simulated during the flow modeling effort. The specific hydraulic parameters and hydrologic features incorporated into the model include (Table 1 and Figure 3):

- Hydraulic Conductivity
- Aquifer Thickness
- Reference Head
- Reference Gradient Magnitude
- Reference Gradient Direction
- Porosity
- Specific Yield
- Areal Recharge
- Wildcat Creek head and flux
- Kokomo Creek head and flux
- Markland Avenue Quarry
- Lagoon Area
- Martin-Marietta Quarry

Model Calibration

The model was calibrated to achieve the best fit possible to the October 2001 upper aquifer groundwater elevation map, and to force the shallow groundwater system to behave in a manner more representative of the flow patterns observed from the distribution of the large contaminant plume in the northeast area of the site. The modifications consisted of decreasing the flux in the line sinks representing the eastern reaches of Wildcat Creek so they would have a less transparent effect on the surrounding flow pattern. Table 1 contains the final calibration parameters and feature values, and Figure 4 shows the final calibration groundwater elevation map.

The groundwater elevations in the Main Plant and Markland Avenue Quarry areas remain generally approximate to observed elevations, except the radial flow observed near the quarry is not as pronounced as it was in the modeled elevations. Also, the groundwater flow pattern in the area north and east of the Main Plant has been altered to approximate the movement of the contaminated plume. Although the October 2001 elevation data are limited in the Lagoon Area, the modeled calibration elevations in this area are still consistent with those observed in previous site investigations (CDM 1997).

Shallow Groundwater Collection Simulations

Inputs to the extraction simulations included the addition of collection system elements (wells) and the reduction of available recharge at Markland Avenue Quarry and the Lagoon Area. Remedies for these areas will result in lower available recharge to the upper aquifer. Because the quarry will be backfilled and covered and the lagoon surface impoundment closed, the additional recharge incorporated into the calibration model for these two areas was removed (Table 1).

Modeling the collection systems involved simulating a system in each proposed area based on the flow modeling to confirm the well spacing calculations (Attachment D-1) and associated flow rates. The zone of groundwater flow from the source areas was estimated through use of particle streamlines. The streamlines are used to represent the path a particle released from the source area would travel in the downgradient flow direction. Particles were placed in the approximate positions of the contaminant plumes upgradient from the proposed collection systems. Figure 5 displays the particle streamline capture zones and the particle release points/areas for each source area. Table 2 summarizes the simulation results, including the total discharge modeled for each collection system. Table 3 presents the expected maximum concentration of primary contaminants at each collection system based on statistical analyses of concentrations reported in nearby monitoring wells.

Contaminated groundwater downgradient of the Markland Avenue Quarry flows northwest toward Wildcat Creek. The flow modeling suggests that groundwater flow from this area could be contained before it discharges into the creek with a well system located on the eastern bank of Wildcat Creek consisting of 6 wells pumping at a rate of 6 gpm each. The collection system would prevent contamination from continuing downgradient, west of Wildcat Creek.

Affected groundwater west of Wildcat Creek is captured at the Millbrook Lane area collection system. The system is designed to capture the center of the large contaminated

plume advecting to the southwest and the affected groundwater west of Wildcat Creek. The five wells in the system are positioned in a transect across the plume and pump at 60 gpm.

The West Markland Avenue collection system was modeled to capture the frontmost edge of the large plume and the contamination downgradient from the Millbrook Lane system. Each of 4 wells pumps at a rate of 10 gpm.

The Markland Quarry extraction system will be installed in the surge rock backfill after the quarry remediation is complete. The system is expected to contain groundwater contamination from the quarry area with a single well pumping at 42 gpm. This design relies on the backfill of the quarry (3- to 4-inch-diameter limestone) to have a higher permeability than the surrounding limestone.

Summary

The amount of water removed from OU1 and discharged to the KWWTP is roughly 180 gpm. The overall configuration of the proposed collection systems across the site is set up in such a way that it allows gradual reduction in the total discharge to the KWWTP over time as specific areas are shut off or their pumping rates are reduced.

References

CDM (Camp Dresser & McKee). *Continental Steel Superfund Site Remedial Investigation Report*. 1997.

CH2M HILL. *Continental Steel Superfund Site, Contract 5–Groundwater, Groundwater Flow, and Quality Conditions*. 2003.

CH2M HILL. *Continental Steel Superfund Site, Contract 5–Groundwater, Aquifer Test Analysis*. 2002.

Environmental Simulations, Inc. WinFlow version 1.07. Developed by Jim and Doug Rumbaugh. 1995.

U.S. Environmental Protection Agency (USEPA) and Indiana Department of Environmental Management (IDEM). *Record of Decision: Continental Steel Corporation Superfund Site. Kokomo, Howard County, Indiana*. 1998.

TABLE 1
Modeled Features and Parameters
CSSS Sitewide Groundwater (OU1) Basis of Design Report

Feature/Parameter	Units	Range of Values	Source	Initial Calibration Scenario Value	Final Calibration Collection Simulation Value
Upper Aquifer Hydraulic Conductivity	ft/day	378–15	Pumping tests completed under Data Acquisition task in 2001.	60	60
Upper Aquifer Thickness	ft	5–55	Similar to above and historic investigation results.	40	40
Upper Aquifer Reference Head	ft	NA	Set during calibration process.	800	800
Upper Aquifer Reference Gradient Magnitude	ft/ft	0.002–0.028	Set during calibration process.	0.005	0.005
Upper Aquifer Reference Gradient Direction	dimensionless	NA	Set during calibration process.	West	West
Upper Aquifer Porosity	dimensionless	0.20–0.50	General hydrogeology literature value range.	0.35[a]	0.35[a]
Upper Aquifer Specific Yield	dimensionless	0.01–0.30	General hydrogeology literature value range.	0.05[a]	0.05[a]
Areal Recharge	ft/day	Assumed 25% of precipitation	National Oceanic and Atmospheric Administration (NOAA) data from 1993 to 2001 in the Kokomo Wastewater Treatment Plant area.	0.0025	0.0025
Wildcat Creek- Constant Head Source/Sink	ft	763–785[b]	1992 Kokomo West Quadrangle Map.	763–785	763–785
Kokomo Creek- Constant Head Source/Sink	ft	780–782[b]	1992 Kokomo West Quadrangle Map.	780–782	780–782
Wildcat Creek- Flux Range	ft/day	NA	General hydrogeology literature value range.	7-28	4-15
Kokomo Creek- Flux Range	ft/day	NA	General hydrogeology literature value range.	10-95	7-35
Markland Avenue Quarry- Recharge Source	ft/day	Assumed 80% of precipitation[c]	--	0.008	Removed
Lagoon Area- Recharge Source	ft	Assumed constant head	--	786	Removed
Martin Marietta Quarry- Constant Head Source/Sink	ft	Assumed dewatering of Upper Aquifer at quarry	--	760	760

[a]The porosity and specific yield values do not impact the discharge estimates developed through the modeling. They would only impact modeling results if groundwater travel or cleanup times were estimated.

[b]Wildcat and Kokomo Creek water elevations were taken from the 1-foot site contour map and extrapolated where necessary using the 1992 Kokomo West Quadrangle Map.

[c]Recharge estimates based on precipitation data for 1993 through 2000 period. Average annual precipitation for that period was 43.8 inches.

TABLE 2

Collection Simulation Summary

CSSS Sitewide Groundwater (OU1) Basis of Design Report

Simulation Description	Layout	Total System Discharge GPM	Total System Discharge GPD
Markland Avenue Quarry			
Proposed Well System	18 wells set along north, west, and south boundaries of the Markland Ave. Quarry. Pumping rate set at 2.3 gpm.	42	60,480
East Bank Wildcat Creek			
Proposed Well System	6 wells set along the east bank of Wildcat Creek, 1,500 ft NW of Markland Ave. Quarry. Pumping rate set at 2.6 gpm.	36	51,840
Millbrook Lane Area			
Proposed Well System	5 wells set parallel to Millbrook Lane on the east side of the road. Pumping is non-uniform, and is set at 12 gpm from north to south.	60	86,400
West Markland Avenue			
Proposed Well System	4 wells set parallel to West Markland Avenue on the north side of the road. Pumping rate set at 10.4 gpm.	42	60,480
Total System Summary	33 extraction wells set at 4 locations.	180	259,200

Notes:
GPM = gallons per minute
GPD = gallons per day

TABLE 3

Maximum Expected Concentrations at Collection System Locations

CSSS Sitewide Groundwater (OU1) Basis of Design Report

Parameter	Markland Ave. Quarry	East Bank Wildcat Creek	Millbrook Lane Area	West Markland Ave.
1,1-Dichloroethene	2	1		2
2-Methylnaphthalene	—	—	1	—
Acetone	7	—	20	—
Aluminum	784	240		112
Aroclor-1248	1.2	—	—	—
Arsenic	—	—	—	10.9
Barium	446	207	138	75
bis(2-Ethylhexyl)phthalate	9	—	—	—
Calcium	213000	172000	128000	484000
Caprolactam	6	150	—	—
Chloroform	9	9	—	—
Chromium	9.3	—	—	4.2
cis-1,2-Dichloroethene	2700	240	360	350
Cobalt	—	—	—	3.4
Iron	39	467	1010	12200
Magnesium	14300	56600	44500	45300
Manganese	67.1	1010	98.8	646
Methylene Chloride	—	25	6	15
Nickel	4.3	15.7	2.1	61.9
Potassium	71000	5720	3510	11300
Sodium	58200	266000	46300	111000
Tetrachloroethene	—	570	15	—
Toluene	—	—	1	—
trans-1,2-Dichloroethene	11	2	—	5
Trichloroethene	440	440	41	4
Vanadium	6.5	—	—	—
Vinyl Chloride	1800	36	11	21
Zinc	26	9.7	3.5	14.2

Note: All units are µg/L.