DOMINION

NORTH ANNA 3 COMBINED LICENSE APPLICATION

NORTH ANNA

GROUNDWATER MODEL

Bechtel Power
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Abbreviations

ft	feet
ft/day	feet per day
ft/ft	feet per foot
ft^2/day	square feet per day
in/yr	inches per year
bgs	below ground surface
msl	mean sea level

Acronyms

AMG	Algebraic Multigrid
BBM	Blue Bluff Marl
ESP	Early Site Permit
GMG	Geometric Multigrid
NRC	Nuclear Regulatory Commission
PCG	Preconditioned Conjugate-Gradient
SER	Safety Evaluation Report
SIP	Strongly Implicit Procedure
SOR	Slice-Successive Overrelaxation
FSAR	Final Safety Analysis Report
USGS	United States Geological Survey
WHS	Waterloo Hydrogeologic Services

1. OBJECTIVE & SCOPE

The objective of this report is to document the development, calibration and use of a groundwater flow model for the North Anna site. The model was used to estimate groundwater levels at the proposed extension of the North Anna Nuclear Power Plant, known as the North Anna Unit 3 site. For design approval, groundwater levels beneath the safety related structures of Unit 3 site must be a minimum of 2 ft below the Design Plant Grade which is at elevation 290 ft NAVD88. This criterion applies to the Reactor Building, Fuel Building, and the Control Building.

The model was developed in 2007 and documented in Bechtel calculation 25161-G-036, Rev 0, dated September 17, 2007. This calculation was revised and issued as Rev 1 on November 2, 2007 to include the Fuel Building, whose foundation is on or near the bedrock, as part of the inactive flow area in the simulation of post-construction model. Selected results of the model were presented in the FSAR. The model was discussed in a meeting between the NRC, Dominion and Bechtel on April 11, 2008. This report provides the information requested by the NRC in the Request for Addition Information (RAI) 2.4.12-1 issued on August 8, 2008.

2. AQUIFER DESCRIPTION & AVAILABLE DATA

2.1 Site Overview

The topography at the North Anna site is gently rolling. The description of surface and groundwater features focuses on the model domain, which extends about 1 mile to the west of Unit 3, about 0.8 miles to the south, and to Lake North Anna, i.e. about 0.5 miles, to the east and north of Unit 3. Local elevation within the model domain ranges from 250 ft NAVD88 up to an elevation of approximately 350 ft NAVD88 with a local relief of approximately 100 ft. Under current (pre-Unit 3) conditions, groundwater flow at the site is generally to the north and east, towards Lake Anna. To the west and the south the area within the model domain is drained by short, intermittent streams that flow to Lake Anna. The water level in Lake Anna is maintained at water level 250 ft NGVD29 (249.14 ft NAVD88) most of the time but has varied between 245.1 ft NGVD29 and 252.0 ft NGVD29.

The finished grade level elevation of the proposed Unit 3 will be approximately 290 ft msl. The bottom of the foundation slab for the reactor building will be 67 ft below grade level, i.e. at elevation 223 ft msl. Figure 1 shows the topography of the site and the location of the existing Units 1 & 2, as well as the planned Unit 3.

2.2 Occurrence of Groundwater and Hydrogeologic Units

Groundwater in the surficial aquifer system at the North Anna site occurs in the fractured bedrock and in unconsolidated materials that are largely weathering products (residual soil or saprolite) of the underlying bedrock. As stated in Reference 1 (page 2-2-140) and supported by Reference 2, "*groundwater in the crystalline rocks is stored and transmitted through joints and fractures in the rocks, while the main body of the rock between the joints and fractures is essentially impermeable. The number and extent of the joints/fractures, and the width of the openings between their surfaces, generally decrease with depth, thus limiting the significance of the water-transmitting capability of the bedrock to its upper few hundred feet*". For the purpose of developing the groundwater model it is assumed that most of the fractures in the bedrock are closed within the first 100 feet below ground surface due to the stresses exerted by the material above. This implies that for all practical purposes groundwater flow is limited to the upper 100 feet below the ground surface.

Two hydrogeologic units are relevant for the development of the groundwater model, the saprolite and the bedrock. The elevation, thickness, and geologic description of the subsurface materials comprising the shallow hydrogeologic units were determined from the North Anna Unit 3 geotechnical and hydrogeological borings.

The saprolite at the North Anna Unit 3 site is generally exposed at the ground surface or underlies a thin layer of residual soil or fill. The lithology of the saprolite varies, depending on the type of parent material from which it was derived. The saprolite encountered on site is classified as a micaceous, silty-clayey, fine to coarse sand or sandy silt, with occasional (less than 10 percent) to some (between 10 and 50 percent) rock fragments.

The bedrock beneath the saprolite is described as quartz gneiss with some biotite quartz gneiss; and interbedded quartz gneiss, biotite quartz gneiss, and hornblende gneiss. The rock exhibits a variable weathering profile and joints/fractures are present, through which groundwater flows. Investigations at the site have indicated that there is a hydrologic connection between the saprolite and the bedrock.

2.3 Groundwater Flow Conditions

Groundwater flow at the North Anna Unit 3 site is generally to the north and east, toward Lake Anna. Three intermittent streams, all of which flow to Lake Anna, are located to the west and south of the site of the proposed Unit 3. Measured groundwater levels are highest in the southwest corner of the model domain. The average hydraulic gradient from the southwest corner of the model domain toward Lake Anna is about 0.04 ft/ft (Reference 3, Table 2.0-201, page 2-64).

There are four well pairs at the site. These wells have been installed adjacent to each other, with one well being sealed in bedrock and the other installed in the saprolite. Nearly equal water level elevations have been recorded in the well pairs, indicating a hydrologic connection between the saprolite and the bedrock. As depth increases, the number of fractures and joints in the bedrock is assumed to decrease until a barrier to vertical flow is achieved.

Groundwater level data from December 2002 through May 2007 are summarized in Table 1. Figure 2 shows the hydrographs of these wells. As can be seen in this Figure the water level data show practically no seasonal or interannual variability.

The groundwater elevation data summarized in Table 1 were used to develop groundwater surface elevation contour maps for the Water Table aquifer on a quarterly basis. These maps are presented in Figures 2.4-207 through 2.4-214 of the FSAR. In each of these maps the spatial trend in the piezometric surface is similar. Figure 3 shows groundwater level contours for May 2007.

Table 1: Groundwater Level Elevations (msl)

well	Well depth*	Reference point el.	Reference point stickup**	Top of screen el.	Well screen length	Date of Measurement							
	Ft	Ft	ft	ft	ft	12-17-02	3-17-03	6-17-03	9-29-03	2-1-05	11-29-06	2-28-07	5-30-07
OW-841	34.3	251.6	1.5	228.1	9.7	248.9	249.6	249.6	249.3	249.1	249.51	249.11	248.74
OW-842	49.6	336.7	1.5	297.8	9.6	307.5	308.9	310.8	312	314.2	313.36	313.84	314.23
OW-843	49.2	320.6	1.5	282.1	9.7	285.1	288.1	290.8	290.2	290.7	288.58	289.78	290.15
OW-844	24.6	273.5	1.5	257.6	9.6	265.5	266.7	267.3	266.4	266.2	266.49	266.32	265.63
OW-845	55	297.3	1.5	253	9.7	272.7	274.9	277.4	277.3	277.1	276.19	276.21	276.86
OW-846	32.7	297.3	1.5	273.5	9.8	272.5	274.8	277.1	277	276.8	276.01	275.95	276.59
OW-847	49.8	319.7	1.5	280.6	9.6	285.4	287	289.5	290.8	293.3	***	***	294.24
OW-848	47.3	284.5	1.5	240.8	5	241.7	242.9	243.6	244	243.2	243.86	243.2	242.63
OW-849	49.8	298.5	1.5	259.4	9.7	265.5	269.5	271.7	270.8	269.5	270.21	***	270.03
OW-901	108	311.3	1.7	214.6	10	N/A	N/A	N/A	N/A	N/A	285.13	286.98	288.46
OW-945	54.5	283.1	1.5	240.1	10	N/A	N/A	N/A	N/A	N/A	***	***	271.59
OW-946	43.4	335.6	1.6	303.6	10	N/A	N/A	N/A	N/A	N/A	302.86	302.8	312.62
OW-947	58	315.1	1.8	268.3	10	N/A	N/A	N/A	N/A	N/A	297.61	297.81	297.92
OW-949	104.5	336.9	1.23	243.2	10	N/A	N/A	N/A	N/A	N/A	313.69	313.9	314.39
OW-950	92	284.5	1.52	203	10	N/A	N/A	N/A	N/A	N/A	239.8	238.68	238.37
OW-951	67.1	250.7	1.01	194.6	10	N/A	N/A	N/A	N/A	N/A	249.44	249.6	249.4
P-10	22.5	286.4	2.4	267	5	274.4	274.8	275.2	275.2	275.3	275.48	275.4	275.17
P-14	N/A	327.1	N/A	N/A	N/A	271.6	272.2	272.8	273.1	273.8	273.99	274.03	274.09
P-18	N/A	329	N/A	N/A	N/A	285.7	286.5	287.5	288.4	289.9	290.48	290.72	290
P-19	58.5	322.3	N/A	N/A	5	284.3	285.2	286.3	287.3	288.9	***	***	290.46
P-20	61	320.6	N/A	N/A	5	274.9	275.4	275.8	275	276.7	277.1	276.95	276.95
P-21	58.5	319.2	N/A	N/A	5	Dry	261.2	262	262.4	263.4	263.74	263.65	263.88
P-22	60	320.5	N/A	N/A	5	276.8	277.8	278.6	278.9	279.5	279.79	279.58	279.45
P-23	41.2	296.4	1.9	258.7	5	261.1	262.6	263.3	263.1	263.5	263.56	263.34	263.35
P-24	25	293.4	2.3	271.3	5	276.4	277.1	278.4	278.3	278.4	278.82	278.8	278.08
WP-3	N/A	317.9(?)	N/A	266.5	5	299.7	301	302.8	302.3	302.1	302.42	302.2	302.09
Lake Anna water level elevation						248.1	250.1	250.4	250.1	250.1	250.1	250.1	249.8
Service water reservoir level elevation						314.6	313.3	314.6	314.6	314.5	314.5	314.4	314.5

Note

- * Below ground surface at time of installation
- ** Above ground surface at time of installation
- *** Valid reading not obtained.

2.4 Net Infiltration

Recharge to aquifers in the Piedmont Physiographic Province site occurs largely as infiltration of local precipitation in interstream areas (Reference 3, Section 2.4.12.12, page 2-2-140). Average precipitation from 1948 to 2006 at the Louisa observing station approximately 12 miles to the west of the site is approximately 43.3 inches/year (Reference 4). Figure 4 shows the total annual precipitation for every year on record at the Louisa observation station. The wettest year on record is 2003, during which the precipitation totaled 71.6 inches. Groundwater elevations measured in 2003 are no higher than during other years (Reference 3). Therefore, the groundwater levels do not appear to be affected by the variability of annual rainfall. Monthly rainfall data at the Louisa observing station are given in Table 2.

The Service Water Reservoir for Units 1 and 2 (Figure 1) is clay lined; however, seepage thru the liner contributes locally to recharge of the groundwater system (Section 3.3.3).

Table 2. Precipitation at the Louisa Observation Station

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
1948	0	0	0	0	0	0	0	12.01	2.23	3.79	6.55	7.66	32.24
1949	5.32	2.34	3.42	3.16	3.21	2.64	7.98	6.81	2.27	2.91	1.78	2.11	43.95
1950	2.2	2.83	3.91	1.53	4.78	1.41	4.47	3.3	6.94	3.46	1.5	3.27	39.6
1951	1.49	2.74	3.56	4.15	1.47	8.1	1.34	2.47	2.71	1.16	5.69	4.78	39.66
1952	5.31	1.98	5.36	5.35	5.84	3.27	1.53	5.18	3.85	1.37	6.91	1.65	47.6
1953	2.34	2.21	5.41	3.49	3.23	3.08	1.29	0.57	1.75	3.43	1.14	4.19	32.13
1954	3.42	1.69	3.85	2.99	4.58	2.63	3.12	3.3	0.47	4.7	2.24	3.73	36.72
1955	0.82	3.5	3.84	3.48	2.9	2.79	4.88	13.12	0.96	2.11	1.53	0.57	40.5
1956	1.28	3.93	2.32	2.54	0.79	2.61	9.22	1.59	6.36	4.65	4.02	3.08	42.39
1957	3.05	4.44	2.03	4.86	2.26	4.76	1.33	3.34	4.64	4.43	4.51	5.13	44.78
1958	3.77	3.88	5.93	3.28	2.19	4.39	4.83	6.52	2.46	2.98	1.75	3.67	45.65
1959	2.3	1.3	2.9	4.01	2.53	4.16	8.12	3.87	1.32	3.56	3.13	2.81	40.01
1960	2.64	5.44	3.43	2.97	4.21	2.6	4.16	3.91	5.19	2.23	1.29	2.2	40.27
1961	2.67	5.78	5.12	3.27	5.4	2.52	3.9	4.69	2.45	8.08	1.78	4.58	50.24
1962	2.59	3.72	5.32	3.27	3.98	4.53	4.07	3.69	3.59	1.01	5.37	3.5	44.64
1963	2.01	2.13	6.4	0.96	1.3	3.4	2.09	3.29	2.53	0.11	6.8	2.17	33.19
1964	4.6	5.7	2.09	3.99	0.56	1.59	3.05	1.86	2.01	3.55	2.23	3.62	34.85
1965	3.47	3.47	4.28	2.58	2.12	3.34	3.36	5.34	2.1	1.79	0.65	0.24	32.74
1966	4.72	4.78	0.92	3.02	3.2	2.49	3.72	1.16	8.61	3.78	1.33	3.61	41.34
1967	1.32	2.47	4.09	1.05	3.9	0.87	3.27	6.98	0.91	3.83	1.94	6.99	37.62
1968	2.99	0.79	3.8	1.81	4.4	6.24	2.87	5.13	1.26	0	3.7	1.97	34.96
1969	2.68	2.6	4.16	1.38	1.82	5.54	5.9	16.33	2.57	1.07	1.6	7.2	52.85
1970	1.53	2.81	3.41	4.45	1.8	0.35	4.1	2.49	1.03	2.83	5.53	2.84	33.17
1971	2.23	5.84	3.27	2.31	10.4	4.63	4.42	4.15	2.82	8.89	3.98	1.27	54.21
1972	2.46	5.38	2.04	3.22	7.49	10.82	5.77	1.81	2.22	10.82	6.88	3.56	62.47
1973	2.67	3.05	3.77	6.1	2.67	2.06	1.94	3.35	3.85	4.7	1.49	6.78	42.43
1974	2.49	1.56	3.3	2.38	3.46	4.37	5.41	2.74	5.49	0.23	1.81	5.16	38.4
1975	3.32	2.34	6.45	1.82	3.36	10.51	7.95	3.07	9.44	1.9	2.02	3.88	56.06
1976	3.65	1.54	2.84	1.61	3.22	4.57	2.68	4.3	4.2	8.78	1.44	1.89	40.72
1977	1.71	0.38	2.45	1.83	1.43	1.52	2.05	2.1	2.04	4.52	5.79	4.96	30.78
1978	8.53	0.29	4.06	3.67	4.77	5.75	5.38	8.26	2.36	1.15	2.58	3.63	50.43
1979	5.55	5.13	3.76	3.34	3.43	3.92	0.9	5.01	7.74	5.49	3.23	0.83	48.33
1980	4.58	1.08	3.83	2.08	3.11	0.56	3.28	4.31	0.91	3.16	2.51	0.4	29.81

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
1981	0.1	3.08	1.35	2.14	4.05	2.11	6.46	3.59	2.74	3.8	0.7	3.54	33.66
1982	2.77	5.01	3.98	2.91	1.99	5.02	2.97	4.34	3.99	2.35	3.27	1.81	40.41
1983	0.93	2.21	4.07	7.17	3.8	3.62	1.52	2.29	2.25	5.25	6.33	5.47	44.91
1984	1.87	6.86	6.64	5.46	4.08	1.17	4.7	4.2	1.86	2.43	3.48	1.66	44.41
1985	2.57	3.25	1.12	0.49	4.79	1.63	6.37	9.33	1.3	5.87	10.88	0.42	48.02
1986	2.13	2.61	1.12	3.18	1.1	0.8	6.17	3.98	1.02	2.62	3.29	5.14	33.16
1987	5.6	1.72	3.62	7.07	4.3	5.35	2.69	1.27	11.14	2.11	6.07	2.99	53.93
1988	3.25	1.96	1.82	1.31	5.32	1.99	4.4	2.96	1.48	1.07	6.9	1.09	33.55
1989	1.49	3.31	5.54	2.41	6.44	8.74	7.77	3.35	4.34	4.21	4.8	2.9	55.3
1990	3.74	2.47	3.57	3.15	9.03	2.89	3.49	3.8	1.19	4.73	1.9	4.35	44.31
1991	4.67	0.98	3.08	2.03	0.92	4.2	11.71	0.48	1.59	1.34	1.63	5.03	37.66
1992	1.75	2.35	2.99	2.68	3.59	2.76	1.42	1.92	5.44	2.58	4.96	5.73	38.17
1993	4.52	2.61	8.78	3.7	4.36	1.77	2.65	2.15	4.43	2.01	9.32	3.15	49.45
1994	3.63	4.53	8.94	1.79	2.11	1.46	6.53	8.13	5.77	1.64	1.69	1.55	47.77
1995	5.35	1.5	2.59	1.79	4.87	5.26	4.98	1.18	2.67	10.31	4.19	2.74	47.43
1996	6.8	3.41	2.73	2.78	3.96	3.02	7.01	2.99	9.45	7.51	3.4	5.56	58.62
1997	2.7	2.6	4.88	2.85	0.7	1.69	5.17	3.63	3.92	3.78	4.93	1.73	38.58
1998	6.21	8.22	6.05	4.35	4.83	3.24	0.52	1.04	1.02	1.43	1.17	2.04	40.12
1999	4.45	2.49	3.68	1.68	1.06	0.76	4.99	4.95	8.96	1.73	2.37	2.16	39.28
2000	2.75	2.11	3.26	4.78	3.02	6.14	2.25	4.07	5.86	0	1.48	0.65	36.37
2001	2.26	1.21	5.16	1.2	4.11	4.91	4.06	2.31	1.47	0.94	0.32	2.14	24.93
2002	1.8	0.82	3.72	3.56	2.27	4.28	6.18	3.92	2.05	5.92	4.68	4.46	43.66
2003	2.64	7.38	5.27	3.83	8.92	8.29	4.55	3.88	10.26	3.69	6.89	5.97	71.57
2004	1.86	2.12	1.99	3.33	7.1	3.3	7.95	6.14	6.95	1.17	5.19	2.54	49.64
2005	3.46	2.19	4.32	3.38	3.94	2.91	3.44	4.89	1.5	8.56	3.13	3.83	45.55
2006	3.31	2.11	0	2.62	3.09	4.64	4.22	2.3	9.49	8.24	6.7	0	46.72
Mean	3.14	3.04	3.8	3.06	3.68	3.69	4.35	4.22	3.75	3.65	3.63	3.32	43.33
S.D.	1.59	1.74	1.74	1.4	2.07	2.3	2.29	2.94	2.78	2.59	2.32	1.82	8.39
Skew	0.94	0.94	0.66	0.85	1.06	1.18	0.72	2.02	1.08	1.02	0.84	0.38	0.87
Max	8.53	8.22	8.94	7.17	10.4	10.82	11.71	16.33	11.14	10.82	10.88	7.66	71.57
Min	0.1	0.29	0	0.49	0.56	0.35	0.52	0.48	0.47	0	0.32	0.24	29.81
No Yrs	58	58	57	58	58	58	58	59	59	58	59	58	55

2.5 Hydraulic Conductivity

Slug tests conducted in 16 wells range in value from 0.02 ft/day ($6.6x10^{-6}$ cm/s) to 9.9 ft/day ($3.5x10^{-3}$ cm/s), with a geometric mean of 1.29 ft/day ($4.5x10^{-4}$ cm/s) (References 1 and 3). Of the wells in which slug tests were performed, 14 were screened in the saprolite, while 2 were screened in the quartz gneiss. No significant difference could be seen between the hydraulic conductivities of the two layers. The available slug test data are given in Table 3 and Table 4.

The average value of the slug tests performed at each well is plotted in Figure 5, which shows a clear pattern of higher conductivity in the north half of the model domain and lower values in the southern half of the model domain. Hydraulic conductivity values south of the fault line were obtained from wells P-10, P-23, P-24, OW-842, OW-844, OW-847, OW-947, and OW-949. The conductivity values for these wells ranged from 0.02 ft/day ($6.6x10^{-6}$ cm/s) to 2.4 ft/day ($8.4x10^{-4}$ cm/s), with a geometric mean of 0.52 ft/day ($1.8x10^{-4}$ cm/s). North of the fault line hydraulic conductivity values were obtained from wells OW-841, OW-843, OW-845, OW-846, OW-848, OW-849, OW-945, and OW-946. The conductivity values for these wells ranged from 1.3 ft/day (4.5×10^{-4} cm/s) to 9.9 ft/day (3.5×10^{-3} cm/s), with a geometric mean of 3.2 ft/day (1.1×10^{-3} cm/s). The ratio of the geometric mean of the hydraulic conductivity between the two regions, north and south of the fault line, is equal to about 6.

Table 3: Hydraulic Conductivity Values from P Series wells

Well ID	Unit Tested	Conductivity Values		
				Average
		cm/s	cm/s	10^{-3} cm/s
P-10 (*)	Saprolite	6.10E-04	6.10E-05	0.3
P-23 (*)	Saprolite	6.60E-05	-	0.1
P-24 (*)	Saprolite	2.90E-04	6.60E-06	0.1

* Slug Test Data for wells P-10, 23, 24 were obtained from Reference 3, Section 2.4.12, as a range of slug test values. It is unknown which values were collected as slug in or slug out.

Table 4: Hydraulic Conductivity Values from Slug Tests by MACTEC (2003, 2007)

Well ID	Unit Tested	Conductivity Values				
		Slug 1 In	Slug 1 Out	Slug 2 In	Slug 2 Out	Average
		cm/s	cm/s	cm/s	cm/s	10^{-3} cm/s
OW-841 (*)	Saprolite	7.80E-04	8.20E-04	-	-	0.8
OW-842 (*)	Saprolite	3.30E-04	3.30E-04	-	-	0.3
OW-843 (*)	Saprolite	4.50E-04	4.90E-04	-	-	0.5
OW-844 (*)	Saprolite	8.90E-05	9.90E-05	-	-	0.1
OW-845 (*)	Quartz Gneiss	6.30E-04	1.10E-03	-	-	0.9
OW-846 (*)	Saprolite	6.80E-04	1.20E-03	-	-	0.9
OW-847 (*)	Saprolite	2.10E-04	2.30E-04	-	-	0.2
OW-848 (*)	Saprolite	1.20E-03	9.90E-04	-	-	1.1
OW-849 (*)	Saprolite	7.00E-04	1.10E-03	-	-	0.9
OW-945 (**)	Saprolite	1.00E-03	-	1.20E-03	1.40E-03	1.2
OW-946 (**)	Saprolite	3.20E-03	2.60E-03	3.50E-03	2.90E-03	3.1
OW-947 (**)	Saprolite	2.40E-04	2.10E-04	1.60E-04	1.90E-04	0.2
OW-949 (**)	Quartz Gneiss	7.00E-04	-	6.70E-04	8.40E-04	0.7

Note

* Reference 5

** Reference 6

2.6 Groundwater Use

Three wells at the North Anna site are used to supply water for use by Units 1 and 2 (Reference 3, Section 2.4.12.1.3). They are Well No. 4 (new), Well No. 6, and Well No. 7. However, these wells are installed at depths of 305 ft, 375 ft, and 730 ft, respectively. These wells are screened in the deeper aquifer which does not communicate with the unconfined surficial aquifer. Therefore they are not included in the present analysis.

2.7 Lake Anna Water Levels

The surficial aquifer discharges into Lake Anna. Groundwater levels in the immediate vicinity of the lake are influenced by the water level in Lake Anna. Twenty nine years of water level observations are available. Figure 6 shows daily measurements of the water level in the lake from October 1978 through October 2007. The water level remains quite close to elevation 250 ft msl, with the exception of few months at the end of the summer and early fall when in many years drops one to two feet below elevation 250 ft msl, and very dry periods, e.g. in 2001-02, when it dropped more. Figure 7 is a duration curve of the water levels shown in Figure 6, giving the percent of time a water level is exceeded. As can be seen in Figure 7, 95 percent of the time the water level in the lake is less than 250.2 ft msl, 85 percent of the time is higher than 249 ft msl, and 95 percent of the time is higher than elevation 248 ft msl.

3. THE GROUNDWATER MODEL

3.1 The Conceptual Hydrogeologic Model

Based on the aquifer description presented in Section 2 the surficial aquifer at the North Anna site was conceptualized as a two layer system. The upper layer represents the saprolite and the lower layer representing the bedrock. The lower boundary of the model is at a depth of 100 ft. This depth was chosen as most fractures should be closed at this depth due to the stresses exerted by the material above.

The model domain was selected in such a manner as to minimize the impact of assumptions regarding boundary conditions on predictions in the area of Unit 3 and its vicinity. The boundaries of the model domain were placed where reasonable assumptions regarding local conditions could be made. Figure 8 shows the selected model domain.

To the north and to the east the model is bounded by Lake Anna. The model extends from Lake Anna to about 7000 ft to the west, and about 7500 ft in the south.

3.2 The Numerical Model

3.2.1 The Numerical Code

The conceptual hydrogeologic model was implemented in a two-dimensional, single layer numerical groundwater model using the code MODFLOW 2000 (Reference 7). MODFLOW solves the three-dimensional ground-water flow equation using a finite-difference method. It has been widely used in the industry since its development and release by the U.S. Geological Survey in 1984.

From its inception MODFLOW had a modular structure that allowed the incorporation of additional modules and packages to solve other equations that are often needed to handle specific groundwater problems (Reference 8). Over the years several such modules and packages have been added to the original code. MODFLOW 2000 is major revision of the code that expanded upon the modularization approach that was originally included in MODFLOW.

To facilitate the development of the present model the user interface Visual MODFLOW (Reference 9) was used. Visual MODFLOW was developed by Waterloo Hydrogeologic Software (WHS), which is now part Schlumberger.

3.2.2 The Numerical Solver

Visual MODFLOW includes several different solvers for the numerical solution of the groundwater flow equations. They include the Preconditioned Conjugate-Gradient (PCG), the Strongly Implicit Procedure (SIP) package, the Slice-Successive Overrelaxation (SOR), the Waterloo Hydrogeologic Services (WHS), the Algebraic Multigrid Method (AMG) and the Geometric Multigrid Solver (GMG) package. After several tests it was determined the WHS solver produced converged solutions in most cases, while most of the other solvers did not. A brief description of the method used by each of the solvers is given in Reference 9.

It was also found that for many combinations of parameters the iterative solution did not converge. To achieve convergence it was necessary to adjust the numerical parameters that affect the solver. A parameter in the WHS solver that was adjusted during several iterations was the "damping factor", which is used to reduce or "dampen" the head change calculated between successive outer iterations. As stated in Reference 9 (page 294) for most well posed groundwater flow problems, a dampening factor of one can be used.

However it was found that in this particular problem a much smaller dampening factor must be used. In some cases it was necessary to use a value as low as 0.1 or 0.05 in order to obtain a converged solution. The effect of reducing the dampening factor is to slow down the convergence speed and increase the number of required outer iterations. In some cases more than 10,000 iterations were needed for convergence.

Another numerical parameter that affects the obtained solution is the head change criterion. This is based on the maximum change between iterations at any cell. A quite small head change criterion was needed in most cases in order to obtain a mass balance discrepancy less than one percent. The default value for the head change criterion used in Visual MODFLOW is 0.01. In most simulations presented in this report a value of 0.005 was used.

3.2.3 The Numerical Grid

Figure 9 shows the numerical grid, the boundaries of the model and the active cells of the model that represent the model domain described in Section 3.1. Grid cells outside this area are inactive. The grid spacing is uniform over the entire model domain, equal to 50 ft. The model covers an area of approximately three quarters of a square mile.

3.2.4 The Vertical Extent of the Model

Vertically the model extends 100 feet below the ground surface. The topography used in the model is based on the site-specific LIDAR aerial survey referenced to NAVD88 conducted as part of COL work for Unit 3, and on USGS Digital Elevation Model (DEM) data for the rest of the model domain. Figure 10 shows contours of the ground surface that defines the top of the model. Figure 11 shows elevation contours for the bottom of upper model layer which represents the saprolite, Figure 12 shows elevation contours for the bottom of lower model layer which represents the fracture rock. These three surfaces define the vertical extent of the two layers of the model.

3.2.5 Types of Boundary Conditions Used in the Model

As explained in Section 3.1, the boundaries of the model domain were selected to coincide with key physical features that allow the definition of boundary conditions. Five different types of flow boundary conditions were used for the development of the model: drain, constant head, recharge and no flow boundaries. A brief description of these five conditions as they are defined and used in MODFLOW is provided below:

- Drain Boundary: The drain boundary condition in MODFLOW is designed to simulate the features that remove water from the aquifer at a rate equal to the product of the conductance of the drain and the difference between the head in the aquifer and a given level associated with the drain. Drain boundaries are used to simulate the effect of agricultural drains or seepage faces where groundwater discharges to the surface. The latter can happen along steep slopes or escarpments. In such cases the drain elevation corresponds to the ground surface elevation. When the water level reaches the ground surface elevation it is removed by the drain boundary. The drain has no effect if the head in the aquifer falls below the fixed elevation of the drain. The conductance of drains used to represent a seepage face is proportional to the area of the drain cells, and depends on the materials near the seepage face that may affect discharge conditions. In general the conductance of drain cells is treated as a calibration parameter.
- Constant Head Boundary: The constant head boundary condition is used to fix the head value in selected grid cells. The effect of the constant head condition

is to provide a source of water entering the system, or a sink for water leaving the system, depending on the head conditions in the surrounding grid cells.

- General Head Boundary: The general head boundary condition allows flow into or out of a cell from an external source in proportion to the difference between the head in the cell and the reference head assigned to the external source. This boundary makes it possible to avoid unnecessarily extending the model domain outward to meet the element influencing the head in the model. Differences between the general-head boundary and the constant head boundary are that a) for the general head grid cells the model solves for the head values, while in the constant head boundary condition the head values are specified, and b) the general-head grid cells do not act as infinite sources of water in contrast to the constant-head cells which do.
- Recharge Boundary: The recharge boundary condition is applied at the ground surface and is used to simulate the effect of groundwater recharge applied. Such recharge represents the net gain of the groundwater system as a result of deep infiltration resulting from precipitation, after the effect of evapotranspiration losses have taken into account. The recharge boundary condition can also used to describe artificial recharge or seepage from a pond.
- No Flow Boundary: This is the default boundary condition in MODFLOW when no other boundary condition is defined. It is used to describe no flow boundaries, such as the groundwater divide, or those resulting from impermeable neighboring materials.

3.2.6 The Numerical Solver

Visual MODFLOW offers the option of selecting from several built-in numerical solvers of the partial differential flow equations. Past experience with Visual MODFLOW has shown that the Waterloo Hydrogeologic Software (WHS) solver performs best in terms of numerical convergence.

The WHS solver was used for all solutions presented in this report. The WHS solver uses two convergence criteria, the head change between successive outer iterations and the residual criterion which is based on the change between successive inner iterations. The head change criterion used was 0.005 ft, and the residual change criterion was 0.001 ft.

3.3 Assumptions

3.3.1 Aquifer Extent

Assumption: The surficial aquifer is limited to the top 100 ft below the ground surface.

Rationale: A discussed in Section 2.2, most fractures in the bedrock are expected to be closed at this depth due to the stresses exerted by the material above.

3.3.2 Flow Boundary Conditions

- Assumption: The intermittent streams along the model boundaries to the east and south of the model domain can be treated as drains.

  Rationale: The groundwater elevation contours based on the interpretation of piezometric data for May 2007 (see Figure 3) show that in the vicinity of the streams near the west and south-southwest boundary of the model domain the groundwater contours are approximately perpendicular to the streams. Therefore, groundwater flow through the eastern and southern boundaries of the model is negligible. Because these streams are ephemeral they can be modeled by designating drain cells in their streambed, with the drain elevation at the invert of each stream (Figure 8). When the groundwater table reaches the top of the drain cells, water is removed from the model (as it would be in an intermittent stream). When the groundwater table is below the top of the drain cells, the streams have no influence on groundwater flow. The value of the conductance of the drain cells was determined by calibration.

- <u>Assumption:</u> Part of the southwest model boundary can be represented by the general head boundary condition.

  <u>Rationale:</u> Flow occurs across the southwest boundary of the site due to groundwater recharge at higher elevations of the hill where this boundary is location. The general head boundary condition can be used to impose the observed 0.04 ft/ft hydraulic gradient (Section 2.3) across the southwest boundary. The part of the model boundary where the general head boundary condition is applied is shown in Figure 8.

  Considering that the groundwater level near the part of the boundary where the general boundary condition is applied is around elevation 320 ft, if the distant water source that is part of the general head condition is at a distance of 1000 ft, then using a gradient of 0.04, the head at that distant source should be at elevation 320+0.04*1000=360 ft. The conductivity at the general boundary can be calculated from the equation:

  $$C=\frac{W\,D\,K}{L}$$

  where

  C is the conductance

  W is the width of the grid cell face exchanging flow with the external source/sink

  D is the saturated depth of the grid cell face exchanging flow with the external source/sink

  K is the average hydraulic conductivity of the aquifer material separating the external source/sink from the model grid

  L is the distance from the external source/sink to the model grid

  The value of the conductance of the general head boundary cells was adjusted during the calibration following the calibration adjustments made to the hydraulic conductivity of the aquifer K.

- <u>Assumption:</u> The bottom of the aquifer can be treated as a no-flow boundary

  <u>Rationale:</u> As discussed in Section 2.2 all joints and fractures are expected to be closed 100 ft below the ground surface. Therefore, the materials at greater depths can be considered practically impermeable, providing a no-flow boundary at the bottom of the model.

- <u>Assumption:</u> The northern and eastern boundary of model along the Lake Anna shoreline can be described as constant head boundaries with a constant head of 249.1 ft NAVD88 (250.0 NGVD29).

Rationale: As discussed in Section 2.7, historic water level data for Lake Anna suggest that its water surface remains relatively constant at approximately 250 ft NGVD29 (see Figure 6 and Figure 7).

- Assumption: Two depressions filled with water near the north-central portion of the site can be described in the simulations of existing site conditions by constant head cells at elevation 225 ft NAVD88 (see Figure 8). These constant head cells are removed in the simulations of future conditions.

  Rationale: These two depressions are currently being pumped down to a level lower than Lake Anna. The water level in these depressions varies, but can be as low as 225 ft NAVD88. After construction of Unit 3 at the site, the water surface in these two depressions will be allowed to equalize at the same level as Lake Anna, and these depressions will be used to supply makeup water to Unit 3.

- Assumption: A third semi-dry depression located just south of the two pumped depressions can be described by drain cells (see Figure 8). These drain cells are removed in the simulations of future conditions.

  Rationale: This depression is allowed to drain freely out through a tunnel to the other two pumped depressions. Therefore the water level in this area never rises and is at most close to the ground surface elevation, but never higher. The drain elevation at the cells within this depression is set equal to the ground surface. After construction of Unit 3 the tunnel between the southern and the two northern depressions will also be blocked and the southern depression will be filled.

3.3.3 Groundwater Recharge

- Assumption: Groundwater recharge in areas occupied by buildings or paved surfaces is zero. These areas can be seen in Figure 13.

  Rationale: Precipitation falling on these areas cannot infiltrate into the subsurface, but runs off and is collected by the existing drainage system at the site; flowing to Lake Anna.

- Assumption: Recharge from the Service Water Reservoir for Units 1 and 2 is higher than in surrounding areas.

  Rationale: Local recharge from seepage thru the clay liner of the Service Water Reservoir for Units 1 and 2 was considered in the groundwater model. Annual seepage rates were varied during the calibration to determine the rate of recharge that gives the best agreement with observed water levels.

- Assumption: Recharge over the rest of the model domain is uniform.

  Rationale: The assumption of a uniform recharge rate was tested by considering variable recharge rates over different areas, based on vegetation cover and ground surface slope. These alternative assumptions did not seem to affect much the calibration of the model. Therefore, it was decided to use a single value of recharge. The different recharge zones used in the model are shown in Figure 13.

3.3.4 Hydraulic Conductivity

- Assumption: The hydraulic properties of the saprolite and the fractured bedrock are not significantly different.

Rationale: The results of slug tests performed in the two materials are similar (see Table 4)

- Assumption: The hydraulic conductivity of the fill material that will be used for the construction of Unit 3 is assumed to be 10^{-3} cm/s.

  Rationale: There are no site-specific data on the hydraulic properties of the materials that will be used for the construction of Unit 3. The assumed hydraulic conductivity value is consistent with a sandy material (Reference 10). To evaluate the effect of this assumption a sensitivity analysis was performed using different hydraulic conductivity values. The results of this sensitivity analysis are given in Section 5.2.1.

- Assumption: The hydraulic conductivity varies across the model domain. For the purpose of developing a groundwater model the hydraulic conductivity distribution can be described by two zones, a higher conductivity zone in the northern half of the model domain, and a lower conductivity zone in the lower half. The dividing line of the two hydraulic conductivity zones coincides with fault "a" (see the 0.6-mile radius site geologic map in Figure 14, reproduced from Reference 1, Figure 2.5-18, page 2-2-429).

  Rationale: As can be seen in the predominant material north of the fault is granite gneiss, massive with some biotite granite gneiss (gn), while south of the fault the predominant material is interbedded hornblende gneiss, biotite granite gneiss and granite gneiss (hgn). The two materials are expected to have different hydraulic conductivity as the result of different weathering rate because of different mineral assemblage. Granite gneiss has more quartz and less biotite than hornblende gneiss. Quartz is expected to be more resistant to weathering and biotite is expected to be least resistant to weathering compared to other minerals found in the gneisses such as feldspar and hornblende. The different weathering rates could lead to different fracture coatings and fracture apertures, both of which could affect rock mass permeability.

  The assumption of the two different hydraulic conductivity zones is also supported by the distribution of the slug test results from several wells (see Figure 5).

- Assumption: All natural materials are assumed to be isotropic.

  Rationale: The validity of this assumption was evaluated by performing model runs were with the vertical hydraulic conductivity, K_v, equal to the horizontal hydraulic conductivity, K_h, and comparing the results with model runs using $K_v=0.1*K_h$. The simulations using $K_v=K_h$ gave better agreement with the data. It is also noted that data from well pairs do not exhibit large vertical gradients.

3.3.5 Steady-State Conditions

- Assumption: Groundwater conditions at the North Anna site can be described by a steady state model.

  Rationale: Groundwater levels are not significantly affected by the seasonal variability in annual runoff. Historical groundwater levels and annual precipitation measurements support this assumption (see Figure 2).

4. MODEL CALIBRATION

4.1 Calibration Target

The model was calibrated for the existing conditions at the North Anna site, with Units 1 & 2 in place, by comparing the model simulated groundwater head values with the observed groundwater levels. Groundwater levels near the North Anna Unit 3 site have been monitored since December 2002. During the monitoring period, observed groundwater levels have exhibited little variability. Reliable data for the greatest number of wells (24) are available for May 2007. These observations were used to calibrate the model. Table 5 gives the locations of the 24 wells used in the calibration, as well as the May 2007 water level elevations. Figure 3 shows groundwater elevation contours based on these data.

Table 5: May 2007 Observed Groundwater Levels used in Model Calibration

Well ID	Easting	Northing	Groundwater Level
	ft	ft	ft NAVD88
OW-841	11,686,804	3,910,556	248.74
OW-842	11,685,149	3,909,035	314.23
OW-843	11,685,057	3,909,725	290.15
OW-844	11,686,590	3,909,909	265.63
OW-845	11,685,741	3,909,859	276.86
OW-846	11,685,722	3,909,845	276.59
OW-847	11,686,448	3,908,945	294.24
OW-848	11,686,273	3,910,853	242.63
OW-849	11,684,731	3,910,786	270.03
OW-901	11,685,917	3,909,772	288.46
OW-945	11,683,793	3,910,136	271.59
OW-946	11,683,823	3,908,788	312.62
OW-947	11,686,372	3,909,580	297.92
OW-949	11,685,153	3,909,025	314.39
OW-950	11,686,285	3,910,842	238.37
OW-951	11,686,786	3,910,521	249.4
P-10	11,687,804	3,909,391	275.17
P-19	11,686,949	3,909,666	290.46
P-20	11,687,344	3,909,798	276.95
P-21	11,687,797	3,909,563	263.88
P-22	11,687,507	3,909,267	279.45
P-23	11,687,869	3,909,524	263.35
P-24	11,687,551	3,909,189	278.08
WP-3	11,685,738	3,907,958	302.09

4.2 Calibration Measures and Statistics

Several parameters providing different measures of the agreement between simulated and observed groundwater levels were used for the calibration of the model. These parameters are defined in terms of the calibration residuals of the water table level defined as the difference between calculated and observed results. The calibration residual, R_i, at a point i is defined as:

$$R_i = {}^{model}X_i - {}^{obs}X_i$$

where

${}^{model}X_i$ is the calculated water level at point *i*

${}^{obs}X_i$ is the observed water level at point

The residual mean, $\bar{R}$, is a measure of the average residual value and is defined by the equation:

$$\bar{R} = \frac{1}{n}\sum_{i=1}^{n} R_i$$

where n is the number of points where calculated and observed values are compared

The absolute residual mean, $|\bar{R}|$, is a measure of the average absolute residual value and is defined as:

$$|\bar{R}| = \frac{1}{n}\sum_{i=1}^{n} |R_i|$$

The Root Mean Squared (*RMS*) residual is defined by:

$$RMS = \left[\frac{1}{n}\sum_{i=1}^{n} R_i^2\right]^{1/2}$$

The Correlation Coefficient, $Cor\left[{}^{model}X, {}^{obs}X\right]$,is calculated as the covariance between the calculated values with the model and the observed water levels at selected points divided by the product of their standard deviations, i.e.:

$$Cor\left[{}^{model}X, {}^{obs}X\right] = \frac{Cov\left[{}^{model}X, {}^{obs}X\right]}{{}^{model}\sigma \, {}^{obs}\sigma}$$

where

$Cov\left[{}^{model}X, {}^{obs}X\right]$ is the covariance between the calculated and observed water levels

${}^{model}\sigma$ is the standard deviation of the calculated values with the model

${}^{obs}\sigma$ is the standard deviation of the observed values

The covariance is calculated using the following equation:

$$Cov\left[{}^{model}X, {}^{obs}X\right] = \frac{1}{n}\sum_{i=1}^{n}\left({}^{model}X_i - {}^{model}\overline{X}\right)\left({}^{obs}X_i - {}^{obs}\overline{X}\right)$$

where

${}^{model}\overline{X} = \frac{1}{n}\sum_{i=1}^{n} {}^{model}X_i$ is the mean of the water levels calculated with the model at n selected points

${}^{obs}\overline{X} = \frac{1}{n}\sum_{i=1}^{n} {}^{obs}X_i$ is the mean of the observed water levels at n selected points

The standard deviation of the water levels calculated with the model is calculated as:

$$^{model}\sigma = \left[\frac{1}{n}\sum_{i=1}^{n}\left({}^{model}X_i - {}^{model}\overline{X}\right)^2\right]^{1/2}$$

The standard deviation of the observed water levels is calculated as:

$$^{obs}\sigma = \left[\frac{1}{n}\sum_{i=1}^{n}\left({}^{obs}X_i - {}^{obs}\overline{X}\right)^2\right]^{1/2}$$

The standard error of the estimate (*SEE*) provides a measure of the variability of the residual around the expected residual value. It is given by the equation

$$SEE = \left[\frac{\frac{1}{n-1}\sum_{i=1}^{n}\left(R_i - \overline{R}\right)^2}{n}\right]^{1/2}$$

The normalized root mean squared (*NRMS*) is the *RMS* divided by the maximum difference in the observed head values. It is given by the following equation:

$$NRMS = \frac{RMS}{{}^{obs}X_{max} - {}^{obs}X_{min}}$$

In addition to calculating the parameters described above for each calibration simulation, Visual MODFLOW also provides a plot of the simulated vs. the observed water level values, which provides a way of visualizing the agreement between model and measured values. An example of such a plot is given in Figure 15. The same figure shows also the range of calculated values for each observed value with 95 percent confidence that the simulation results will be acceptable for a given observed value. In a successful calibration the line representing the perfect match between modeled and observed values, i.e. the line along which the modeled values are equal to the observed values, should be within the 95% confidence interval. The plot of simulated vs. observed water levels shown in Figure 15 also shows the 95% interval, defined as the interval where 95% of the total number of data points are expected to occur.

Finally, an additional measure of the adequacy of each run is the discrepancy between inflows and outflows from the model domain. To satisfy the overall mass balance, this discrepancy should be zero. In practice though, this may not be possible. The aim in calibrating and developing the groundwater model for the North Anna site was to make the mass balance discrepancy as small as possible. The mass balance discrepancy, M_d, is calculated using the following equation:

$$M_d = \frac{V_{in} - V_{out}}{\frac{1}{2}\left(V_{in} + V_{out}\right)}$$

where

V_{in} is the total flow into the model domain

V_{out} is the total flow out of the model domain

Most of the calibration measures and statistics discussed above are reported for all the simulations leading to the calibration of the model presented in this report.

4.3 Calibration Criteria

Using the calibration measures and statistics the following criteria were used for calibration of the model:

a. Root mean squared residual *RMS* < 5 ft

b. Normalized root mean squared residual *NRMS* < 10 percent

c. Absolute value of maximum residual < 6 ft

d. Mass balance discrepancy M_d < 1 percent

e. A simpler model that meets these criteria is preferable over a more complex model that also meets the same criteria.

4.4 Calibration Parameters

The primary calibration parameters were the hydraulic conductivity and the aquifer recharge rate. These two parameters were varied to achieve satisfactory agreement between simulated and observed water levels according to the calibration criteria stated in Section 4.3.

The calibration effort started with the simplest set of assumptions, a uniform hydraulic conductivity value over the entire model domain and a uniform recharge. Zones of different hydraulic conductivity and groundwater recharge zones were progressively introduced where their presence could be supported by local conditions and where it seemed to improve the calibration of the model.

The calibration was achieved through a series of simulations using different values of the key parameters involved. The best agreement between computed and observed groundwater levels was obtained when two zones of hydraulic conductivity, roughly divided along Fault "a" were used (see Section 3.3.4 and Figure 5). The best agreement with the observed water levels was obtained using a hydraulic conductivity of 6×10^{-4} cm/s north of the fault and a hydraulic conductivity of 2×10^{-4} cm/s south of the fault. Both of these values are within the range of hydraulic conductivities from slug tests for their respective zone.

The calibrated value of groundwater recharge over natural terrain and graded unpaved areas (zone R_1 in Figure 13) was 9 in/yr. This is about 21% of the mean annual rainfall. The calibrated value of groundwater recharge over the Service Water Reservoir for Units 1 and 2 (zone R_3 in Figure 13) was 25 in/yr.

4.5 Calibration Results

Figure 16 shows the computed heads in layer 1 and Figure 17 shows the computed heads in layer 2 obtained with the calibrated model. Comparing Figure 16 and Figure 3 suggests that the calibrated groundwater model reproduces well the salient features of the flow pattern based on the interpretation of the measured water levels. Figure 18 and Figure 19 show the residuals for the wells screened in layers 1 and 2 respectively. Figure 20 plots the observed versus the computed groundwater levels for all the wells and gives the basic calibrations statistics. The discrepancy between all inflows into and outflows from the model was 0.13 percent.

Figure 21 and Figure 22 show the simulated heads and residuals in the immediate vicinity of Unit 3 and in layers 1 and 2 respectively. As can be seen in these two Figures, in the vicinity of the Unit 3 Power Block the observed head values exhibit a steep hydraulic gradient that is not reproduced by the model. As a result, calibrated head values beneath the Reactor Building are approximately 7 ft lower than measured (see the residual at well OW-901 in Figure 22). It is noted that well OW-901 is about 200 ft from and about 14 ft upslope of observation well OW-845 and the measured heads at these two wells in May 2007 (288.46 and 276.86 ft respectively as shown in Table 5) differ by 11.6 ft. For the 5 quarterly measurements available, head differences at these two wells range from 8.6 to 11.6 ft with an average difference of 9.9 ft. It is also noted that the top of the well screen in OW-901 is at elevation 214.6 ft (see Table 1), which is 38.4 ft below the top of the well screen in OW-845 at elevation 253 ft. The difference in the measured heads between these two wells is likely due to local heterogeneities in the distribution and characteristics of fractures in the bedrock, which cannot be accounted for in the model. In general, the data from well pairs suggest that the vertical gradient is small. The nearest well pair to OW-901 is OW-845 and OW-846, screened at elevations 253 ft and 273.5 ft, respectively. The measured heads at the two wells differ by 0.3 ft (see Table 5), with the deeper well (OW-845) having a higher head.

Given the difference in the measured heads between wells OW-845 and OW-901, the calibration of the model aimed at producing model heads in the area of the two wells that are between the measured values. As can be seen in Figure 22, the model predicts a higher than observed head at well OW-845, where the residual is +3.75 ft, and a lower than observed head at well OW-901, where the residual is -7.09 ft. To assess the significance of the fact that the simulated heads at well OW-901, located at the proposed Unit 3 reactor building, are lower than observed, a sensitivity analysis was performed as described in Section 5.2.2. In this sensitivity analysis an alternative calibration of the model is presented where the heads at OW-901 are matched.

The calibrated groundwater levels reflect the best overall match that can be obtained at present. Because of the inherent spatial variability in aquifer hydraulic conductivity associated with fractured bedrock systems, and potential spatial variability in actual infiltration versus runoff, it was to be expected that the model would not produce an exact match with the observed groundwater levels.

5. POST-CONSTRUCTION SIMULATIONS

For the construction of North Anna Unit 3 the existing site will be graded to create a flat pad for the planned footprint of the new unit. Unit 3 will have a finished grade level elevation of approximately 290 ft msl. In the area of the power block, the hillside will be excavated to create a flat pad for the buildings. The hillside near the Unit 3 cooling tower will also be excavated for the same purpose. Figure 23 shows the topography of the model domain after the completion of the site grading for Unit 3. Excavations will also be completed for the building foundations. The Reactor Building, Fuel Building, Control Building, Radwaste Building, and Turbine Building will have their foundations on or near the bedrock. The bottom of the foundation slab for the reactor building will be at elevation 223 ft msl.

5.1 Post-Construction Groundwater Simulations

Groundwater flow simulations for post-construction conditions were performed with the calibrated model. For the simulation of post-construction conditions the following modifications were made to this model:

a. The topography used in the model was modified to reflect the final grading of the site after the completion of the construction of Unit 3 as shown in Figure 23.

b. A new hydraulic conductivity zone was introduced to describe the backfill material in the area around the power block of Unit 3. This new zone is shown in Figure 24. The hydraulic conductivity of the fill material used in the model was 10^{-3} cm/s. As discussed in Section 3.3.4, this order of magnitude value was assumed due to lack of site-specific information about the fill that will be used for the construction of Unit 3. To account for the uncertainty in the hydraulic properties of the fill material, a sensitivity analysis of the hydraulic conductivity of the fill was performed, and is presented in Section 5.2.1.

c. The rate of groundwater recharge in the area affected by the construction of Unit 3 was changed to reflect post-construction conditions. The basic change in recharge was that a zero value was assigned to areas of new buildings, parking lots and other paved areas. The groundwater recharge zones used in the post-construction simulations are shown in Figure 25

d. Model cells representing buildings whose foundation extends to or near the bottom of the upper model layer were removed from the model domain (in the upper layer only) and designated as inactive. This was to account for the fact that the buildings represent barriers to groundwater flow.

e. Drain cells were added to the model to represent the drain system planned around the power block and the cooling tower areas. The location of the drains was obtained from References 11 and 12. Figure 26 shows the drain cells used in the post-construction model. The drain elevations were set at 282 ft NAVD88 around the Power Block and at 286 ft NAVD88 around the cooling tower.

Figure 27 shows the simulated groundwater levels with the post-construction model. Figure 28 shows groundwater elevation contours in more detail in the area of the Unit 3 power block. In this simulation the discrepancy between all inflows into and outflows from the model was 0.47 percent.

As seen in Figure 21, the maximum groundwater elevation beneath the safety related buildings is approximately 281 ft NAVD88 elevation, which equates to a depth to water below Design Plant Grade of 9 ft. Beneath the power block, the water table elevation ranges from 269 ft to 282 ft NAVD88. The minimum 2 ft depth to water requirement is met over the entire power block area.

5.2 Sensitivity Analysis

Sensitivity analysis simulations were performed to assess the effect of the uncertainty in two parameters on predicted groundwater levels in the power block area. The sensitivity analysis focused on the hydraulic conductivity of the fill material and the groundwater levels upgradient of the power block area. As discussed in Section 4.5 the simulated groundwater head at well OW-901 was 7.1 ft lower than what was measured.

5.2.1 Hydraulic Conductivity of the Fill

The hydraulic conductivity of the fill was varied by one order of magnitude above and below the base value of 10^{-3} cm/s to investigate the change in groundwater level beneath the Power Block. By increasing the value of the hydraulic conductivity by one order of magnitude to 10^{-2} cm/s, the maximum water table elevation beneath the safety related buildings decreased to approximately 279 ft NAVD88 elevation.

A decrease in the hydraulic conductivity of one order of magnitude to 10^{-4} cm/s increases the maximum water table elevation beneath the Unit 3 safety related buildings to approximately 282 ft NAVD88 elevation or a depth to water below Design Plant Grade of 8 ft. Beneath the entire Unit 3 Power Block area, the water table elevation ranges from 269 ft to 283 ft NAVD88. The minimum 2 ft depth to water requirement is met for the entire Power Block. Groundwater levels in the area of the Unit 3 Power Block simulated for this case are shown in Figure 29.

5.2.2 Groundwater Levels

The calibration obtained could not reproduce the steep hydraulic gradient upgradient of the Unit 3 Power Block. As a result, the simulated heads at the site of the future Reactor Building are lower than those measured. For example, at well OW-901 the simulated head is about 7.1 ft lower than the calibrated value. In order to investigate the effect of this discrepancy between model and observations on the simulated groundwater levels beneath the Power Block, the groundwater recharge was increased until the pre-construction calibrated and observed water levels approximately matched at OW-901. By increasing the rate of recharge over zone R_1 to 12.5 inches per year, the residual at well OW-901 is reduced from 7.1 to 0.2 ft. Figure 30 and Figure 31 show the simulated heads and residuals obtained from under this assumption. Even though the assumption of a higher recharge rate improves the agreement of the model with the observed head at well OW-901, the overall agreement of the model with the data is not as good as for the calibrated model presented in Section 4.5. This is illustrated also in Figure 32 which shows the observed vs. computed heads for this simulation.

The effect of increasing the rate of groundwater recharge on the power block area is to raise the maximum post-construction water table elevation beneath the safety related buildings to approximately 283 ft NAVD88 elevation or a depth to water below Design Plant Grade of 7 ft. Beneath the entire Unit 3 power block area, the water table elevation ranges from 271 ft to 283 ft NAVD88. The minimum 2 ft depth to water requirement is still met for the entire power block. Groundwater levels generated by this sensitivity case are shown in Figure 33.

These results were expected based on the location and elevation of the drains around the Power Block. These drainage ditches effectively control the groundwater levels around the

Power Block. Therefore, there is little change in predicted water levels between the calibrated model and those obtained in the sensitivity analysis.

6. CONCLUSIONS

A two-layer model was developed to simulate groundwater flow under present and post-construction conditions at the North Anna site. The model was developed using all available historic data and data collected in support of the ESP and COL applications.

- As shown on Figure 28, the post-construction water table elevation at the safety related buildings is expected to be 269 ft to 281 ft NAVD88 with a minimum depth to water of 9 ft. Beneath the entire Power Block the maximum water table elevation is expected to be 282 ft NAVD88. The 2-ft minimum depth to water requirement is met for all the safety related buildings, as well as for the other buildings in the Power Block.
- Decreasing the hydraulic conductivity of the fill by one order of magnitude raises the expected water table elevation beneath the Unit 3 safety related buildings to 269 ft to 282 ft NAVD88 with a minimum depth to water of 8 ft (Figure 29). The 2-ft minimum depth to water requirement is met for all the safety related buildings, as well as for the other buildings in the Power Block.
- Increasing the recharge to better match the water levels reported at well OW-901, located at the site of the future Unit 3 Reactor Building, results in expected water levels beneath the Unit 3 safety related buildings of 271 ft to 283 ft NAVD88 with a minimum depth to water of 7 ft (Figure 33). Again, the 2-ft minimum depth to water requirement is met for all the safety related buildings and also for the other buildings in the Power Block.

The calibration obtained does not match all groundwater levels in the area of the North Anna Unit 3 Power Block. A sensitivity analysis was conducted by increasing the recharge to better match the water levels reported at well OW-901. Under the assumption of a higher recharge the water levels at other wells are overestimated, i.e. this assumption produces higher overall groundwater levels in the area of interest and therefore represents a bounding, high-water table condition. Even for this extreme case the 2-ft minimum depth to water requirement is easily met.

7. REFERENCES

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2. Pavlides, L., 1980: Revised Nomenclature and Stratigraphic Relationships of the Fredericksburg, Complex and Quantico Formation of the Virginia Piedmont, U.S. Geological Survey, Professional Paper 1146, 1980.

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4. Southeast Regional Climate Center (SERCC): http://www.sercc.com/cgi-bin/sercc/cliMAIN.pl?va5050 (accessed 07/24/2007)

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7. Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G., 2000, MODFLOW-2000, the U.S. Geological Survey modular ground-water model - User guide to modularization concepts and the Ground-Water Flow Process, U.S. Geological Survey Open-File Report 00-92, 121 p.

8. McDonald, M.G., and Harbaugh, A.W., 1984, A modular three-dimensional finite-difference ground-water flow model, U.S. Geological Survey Open-File Report 83-875, 528 p.

9. Waterloo Hydrogeologic Inc., Visual MODFLOW Professional v.4.2, User's Manual, 2006.

10. Freeze and Cherry, 1979. Groundwater, Prentice Hall

11. Bechtel Power Corporation, 2007. Dominion North Anna Unit 3 Cooling Tower Area Finish Grading Plan. Drawing 0-CS-0200-00001 Rev. 0A

12. Bechtel Power Corporation, 2007. Dominion North Anna Unit 3 Power Block Finish Grading Plan. Drawing 0-CS-0100-00001 Rev. 0C

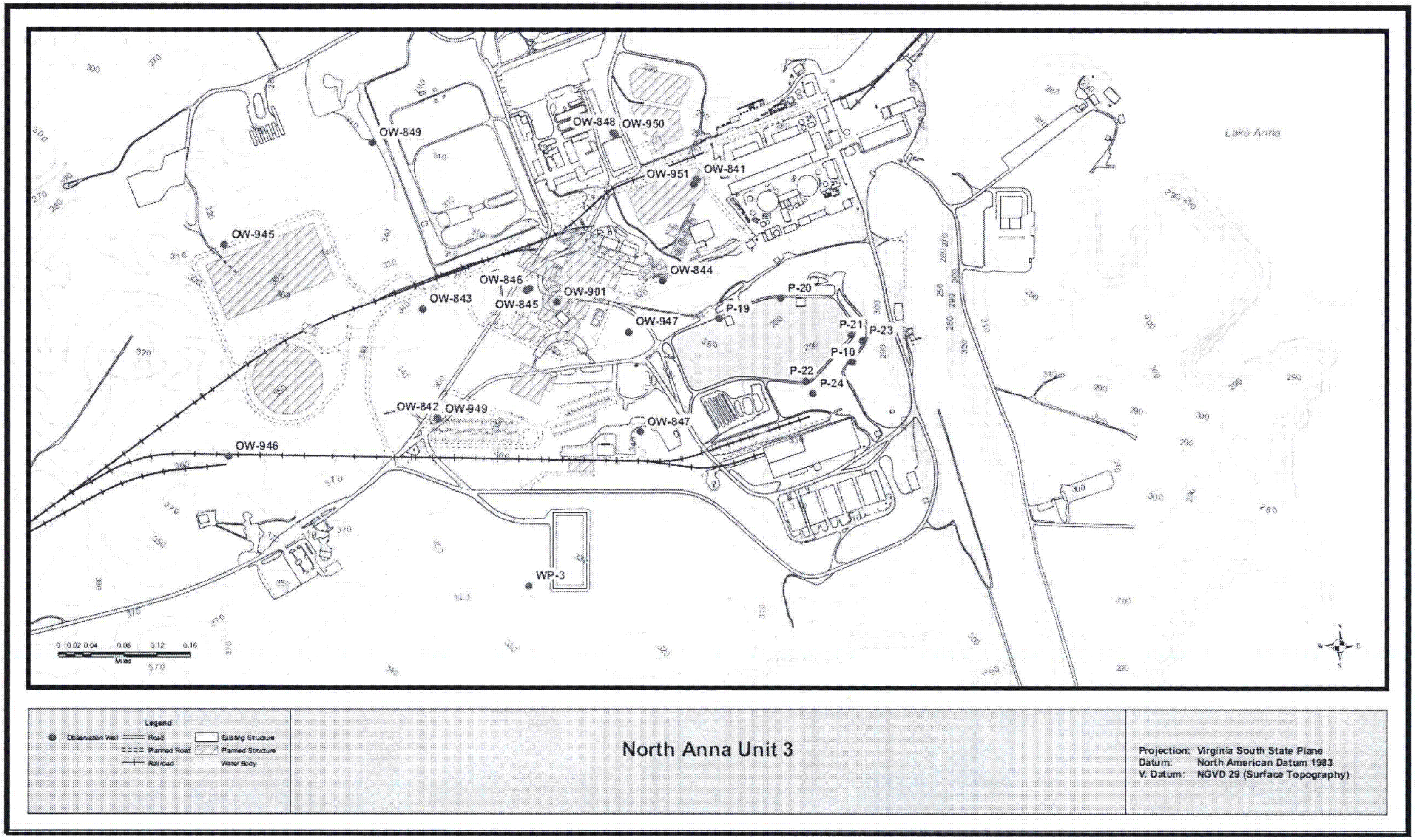


Figure 1. Site map showing the existing and the proposed structures (Figure 2.4-206 in Reference 3)

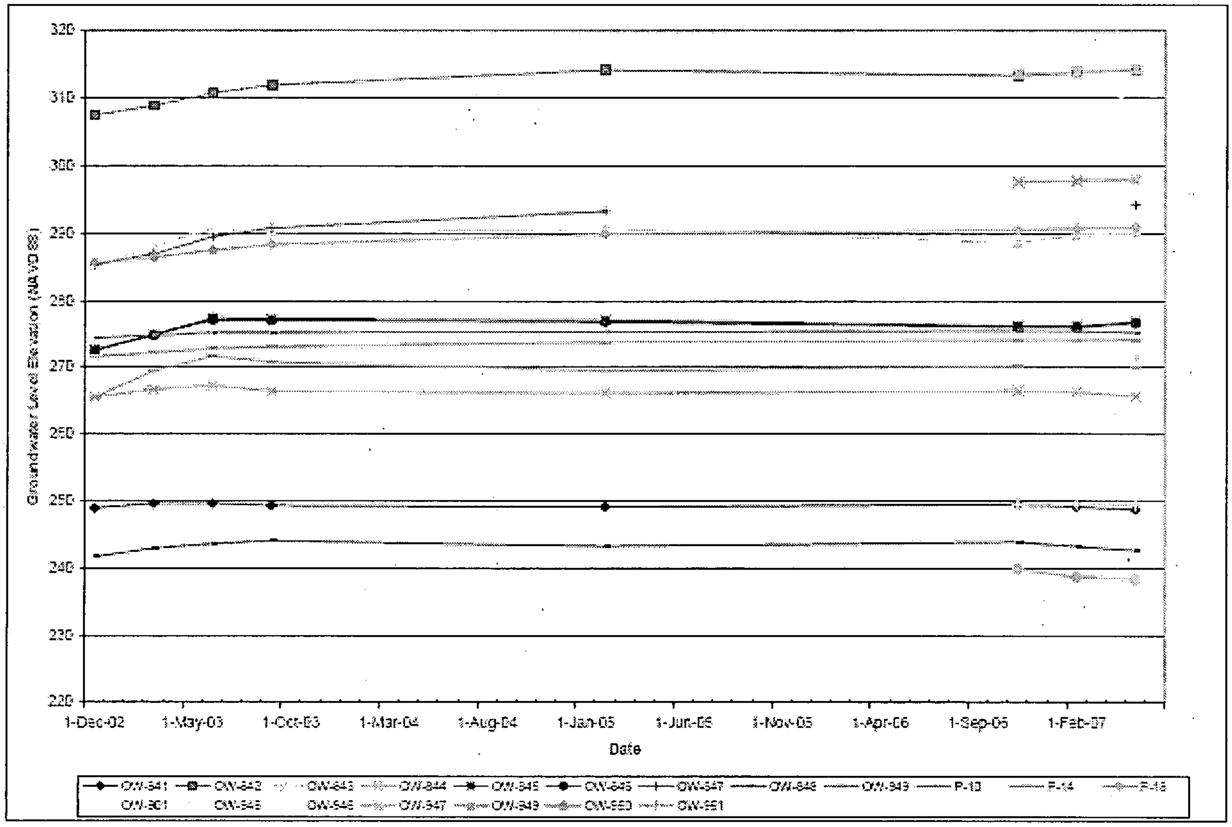


Figure 2. Groundwater Level Hydrographs (Figure 2.4-205 in Reference 3)

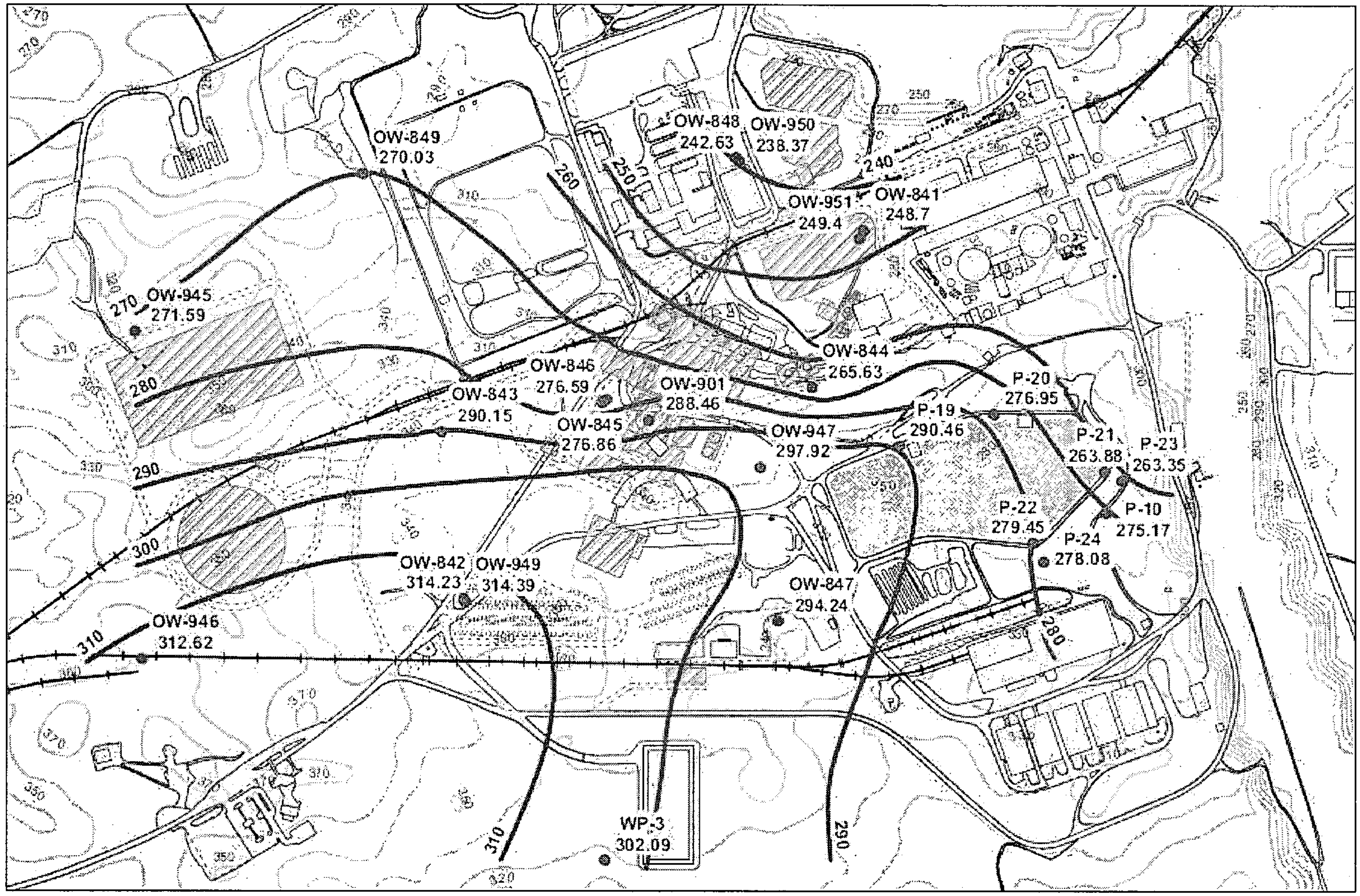
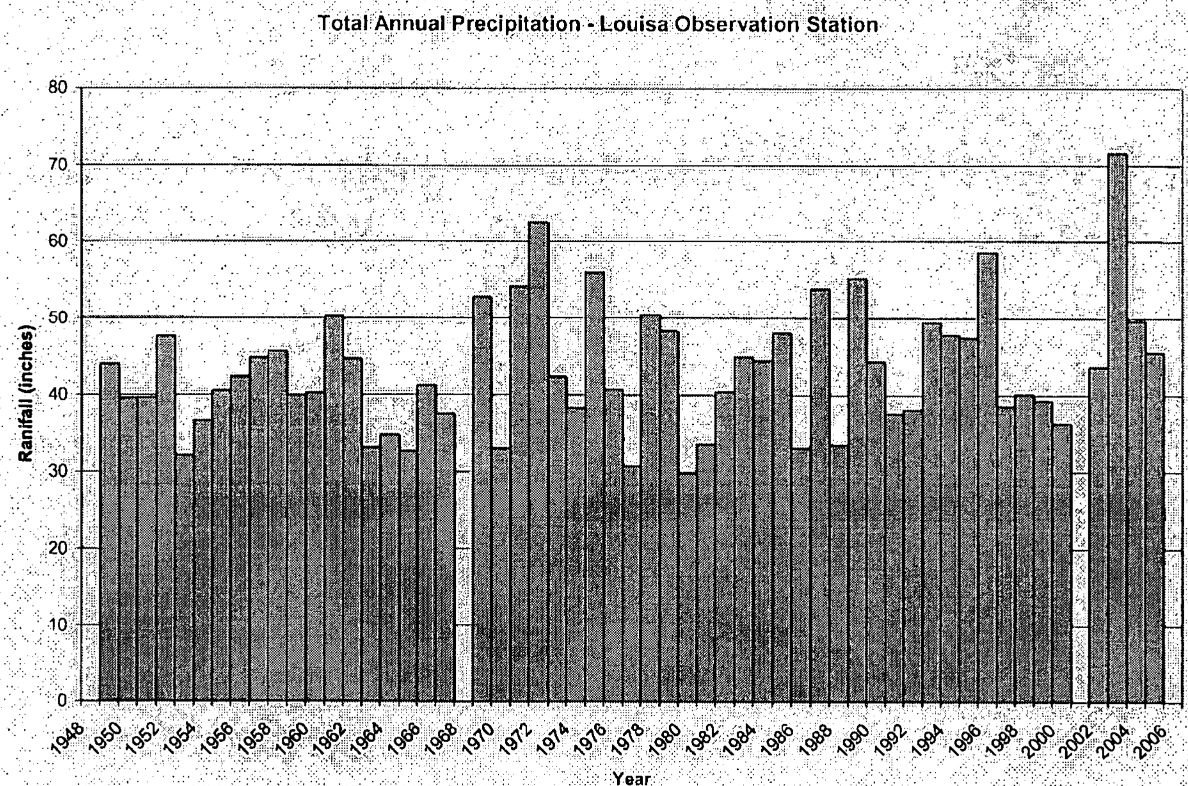


Figure 3. Measured groundwater levels in May 2007 (Figure 2.4-214 in Reference 3)



Note – Monthly precipitation data at the Louisa observation station for the years 1948, 1968, 2001, and 2006 was incomplete; hence, total annual precipitation data is not available.

Figure 4. Annual precipitation at the Louisa observation station, Louisa, Va

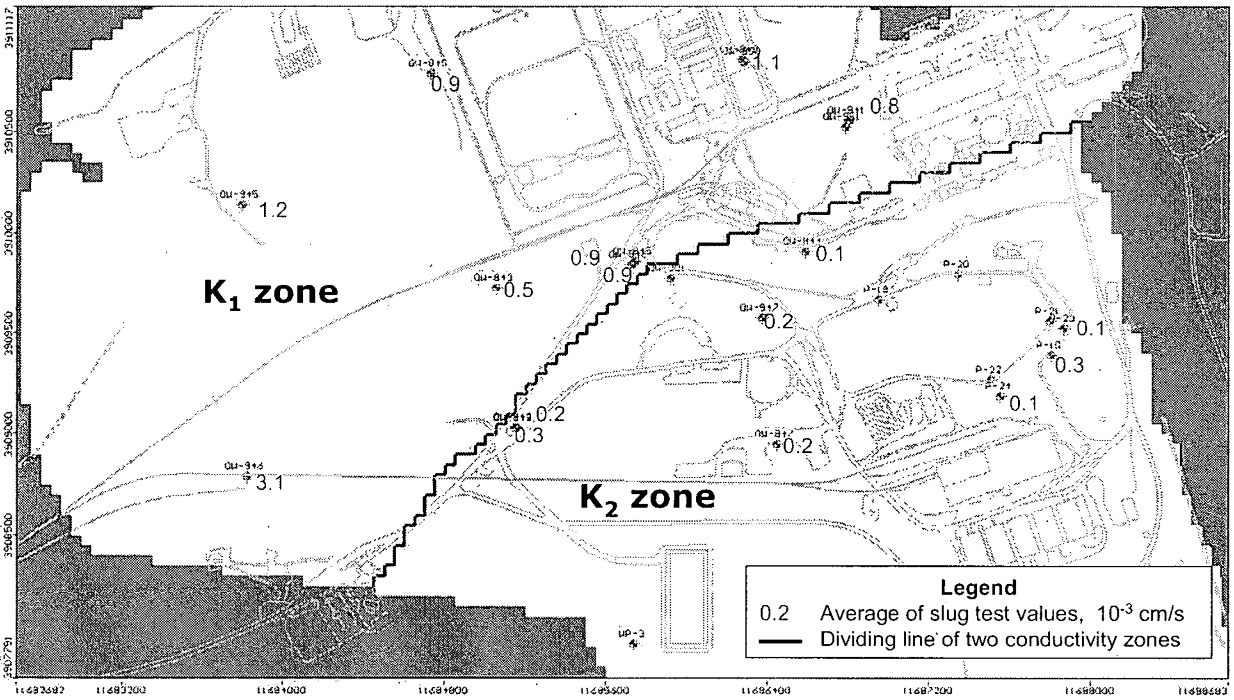


Figure 5. Average hydraulic conductivity values (10^{-3} cm/s) from slug tests

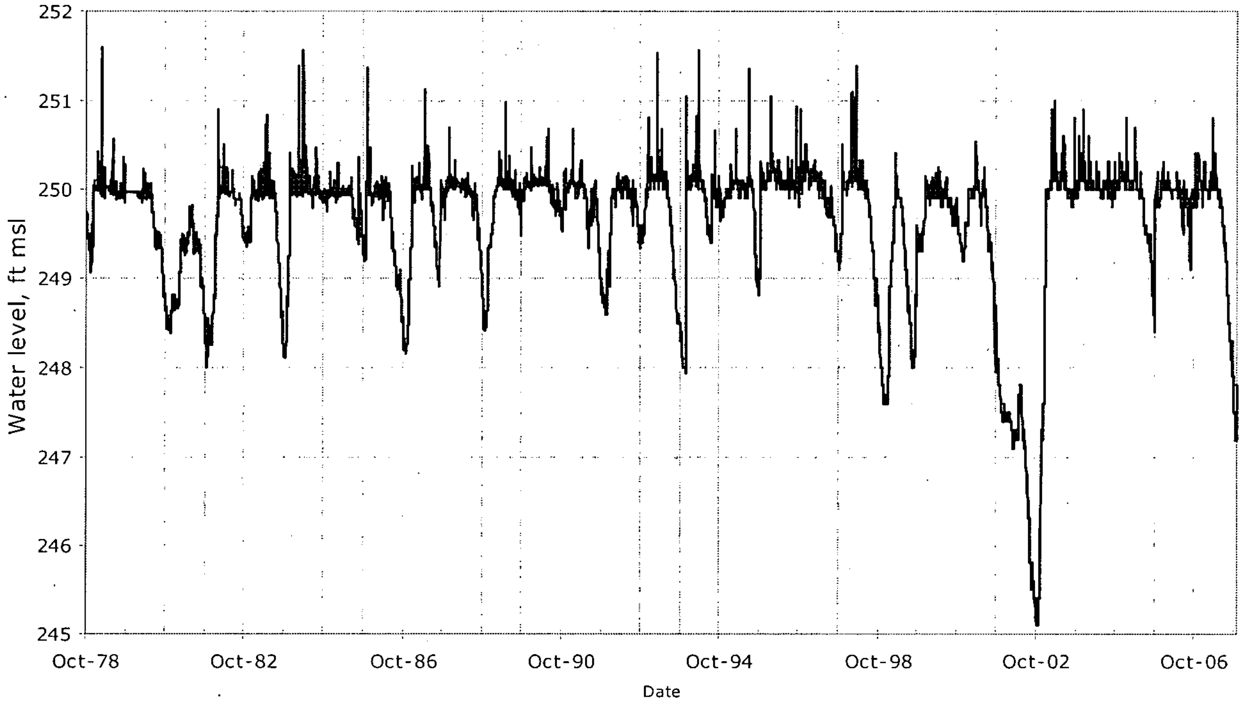


Figure 6. Lake Anna water level from 1978 through October 2007

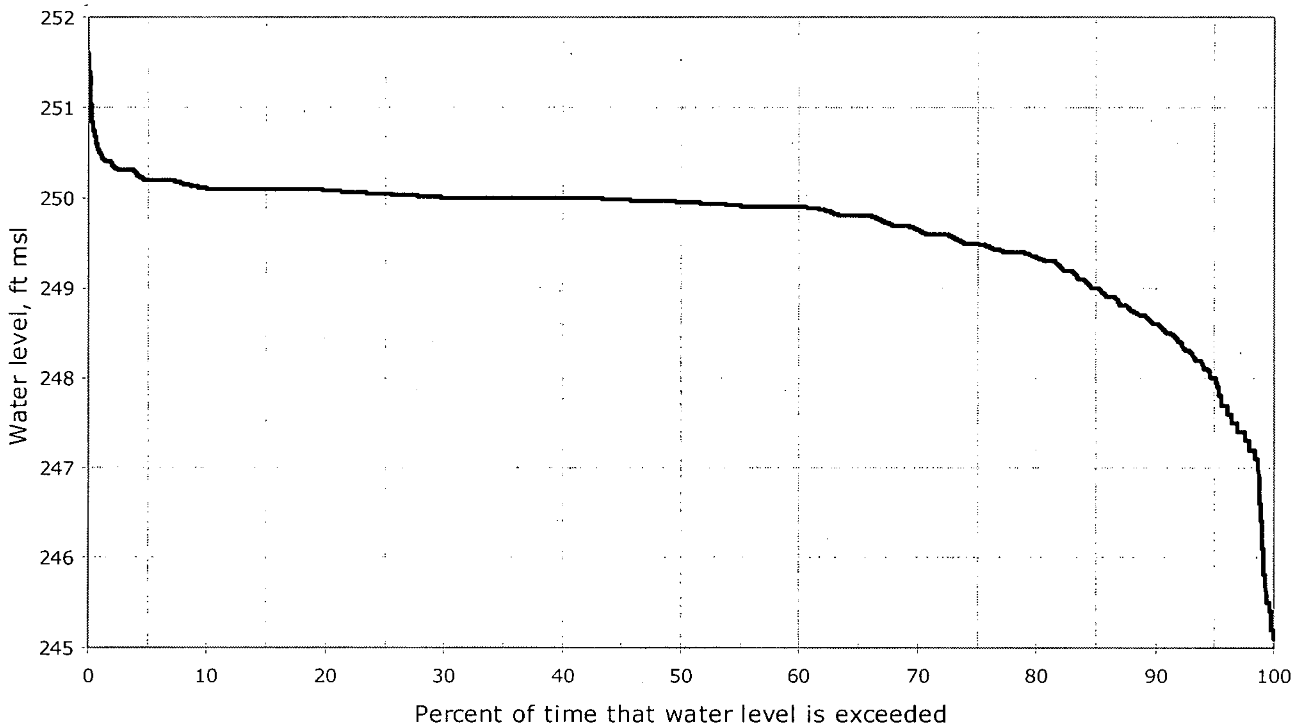


Figure 7. Duration curve of Lake Anna water levels

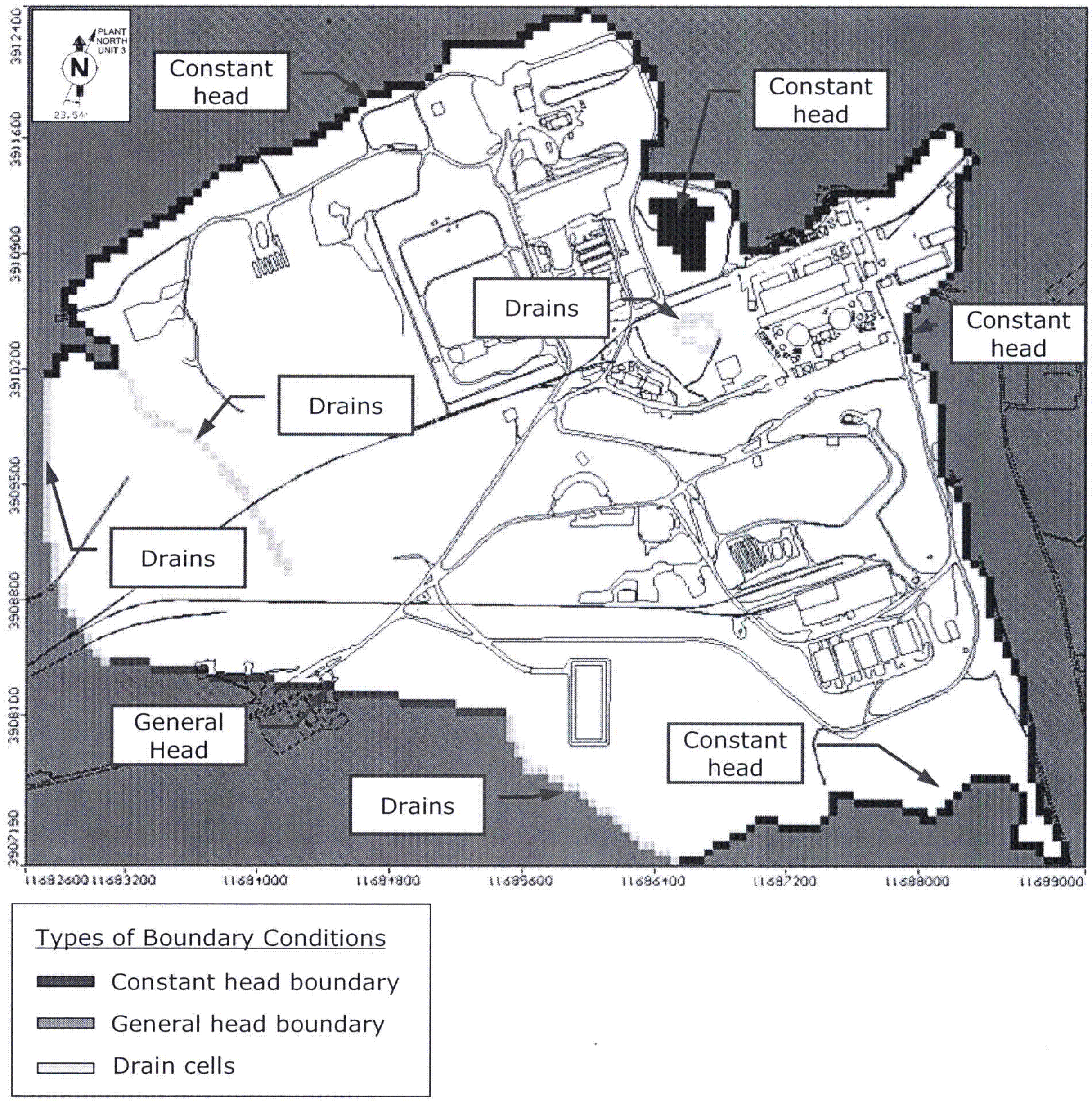


Figure 8. Boundary conditions

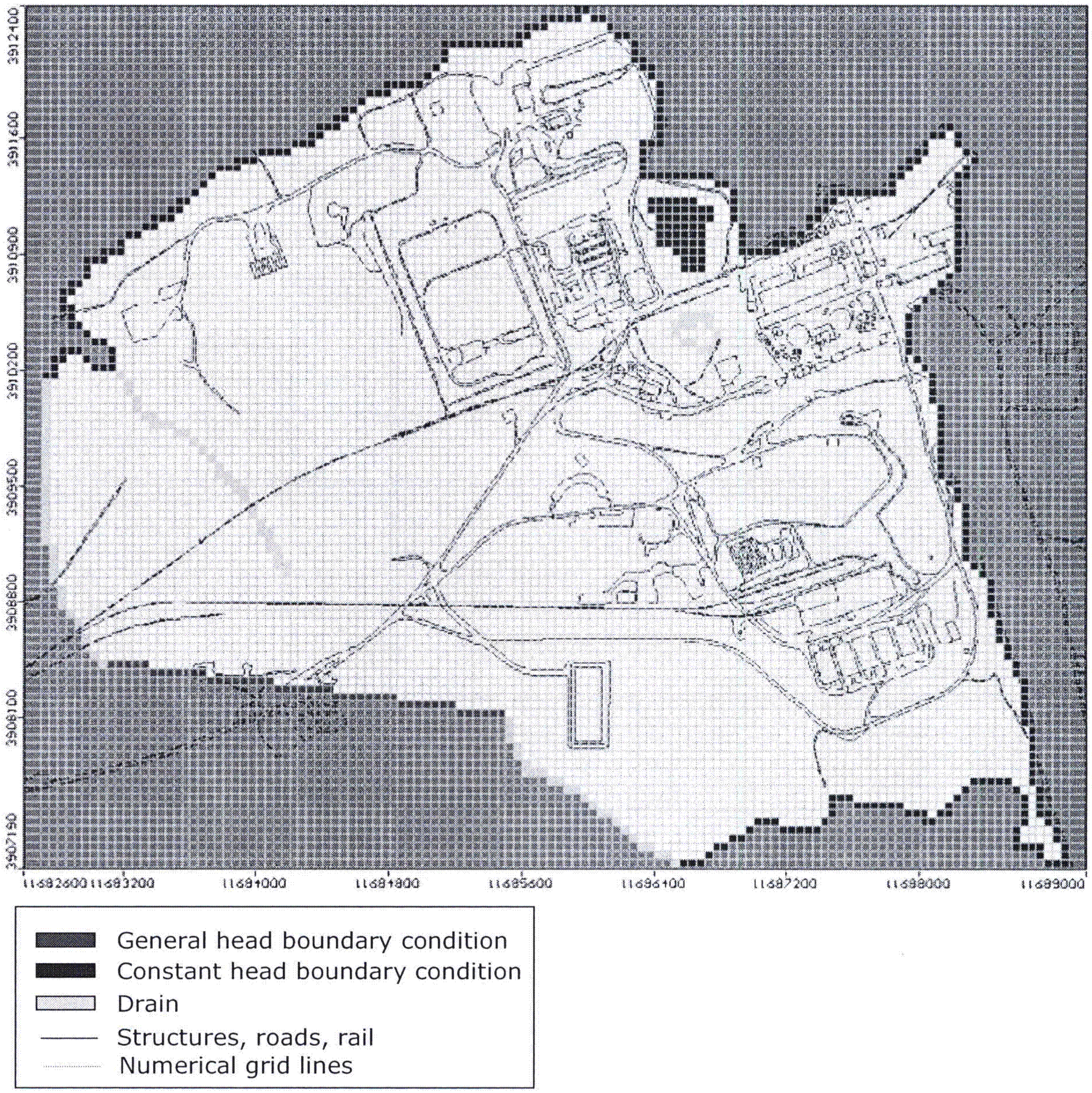


Figure 9. Numerical grid

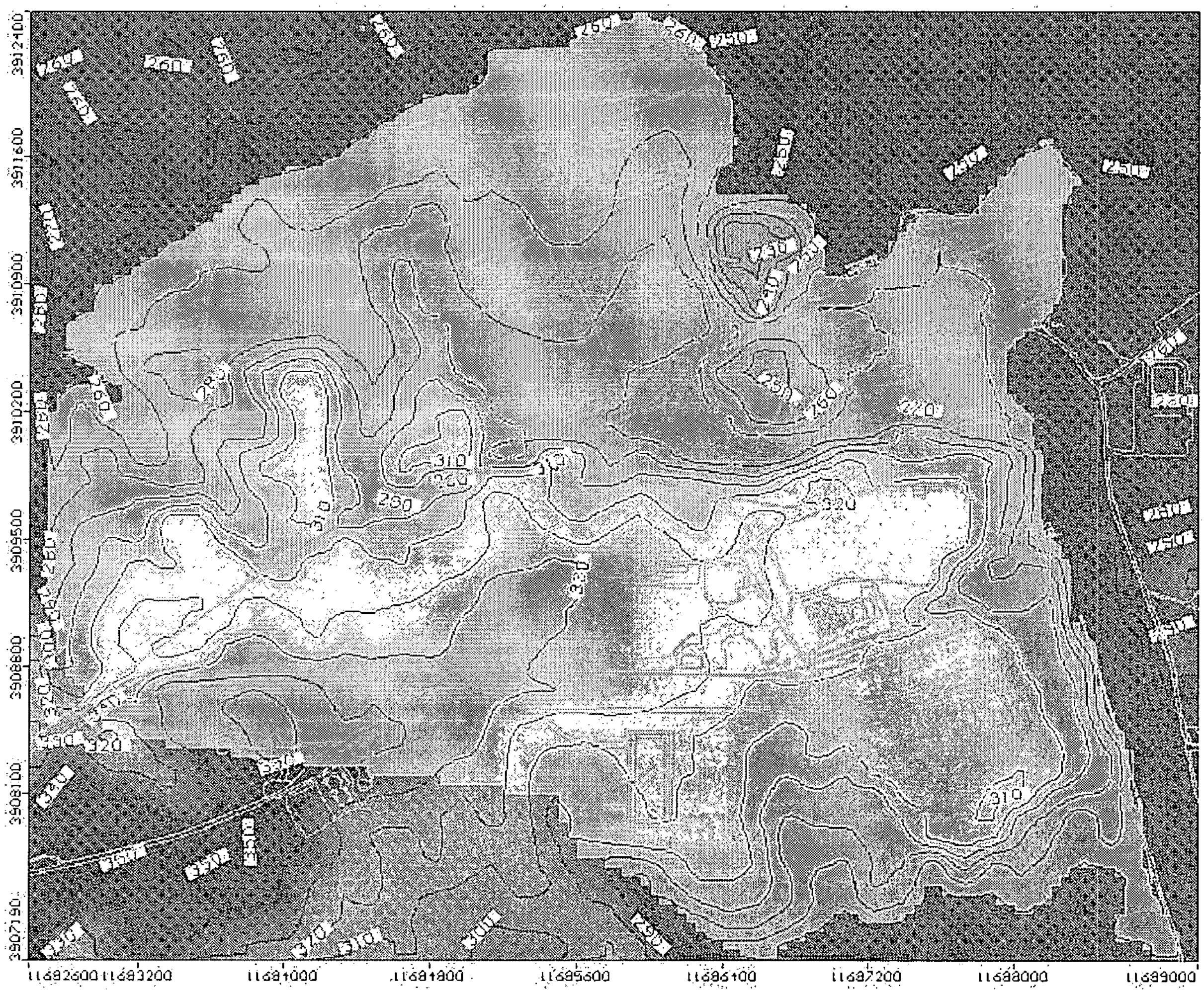


Figure 10. Ground surface elevation used in the model

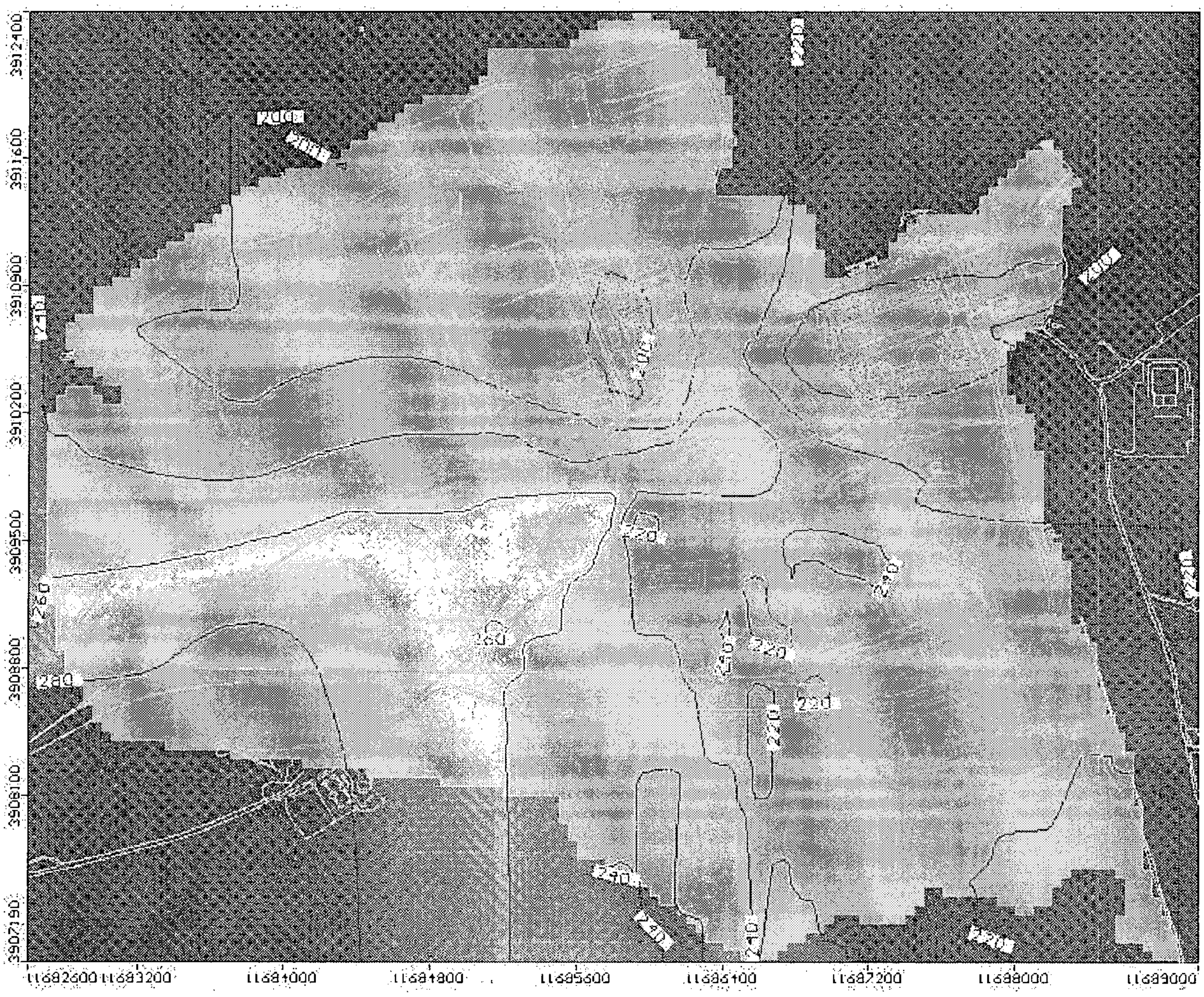


Figure 11. Bottom surface elevation of the top model layer

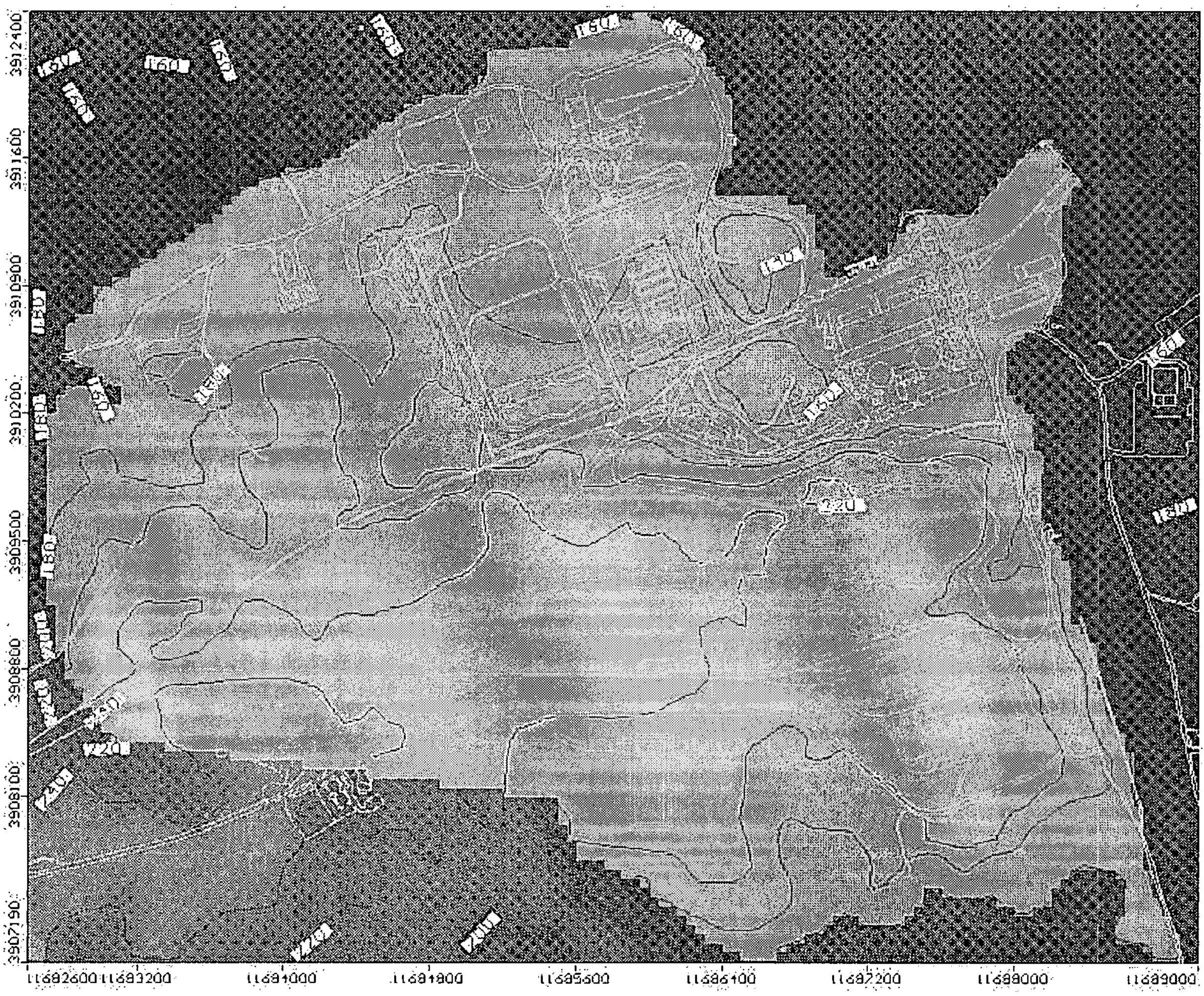


Figure 12. Bottom surface elevation of the bottom model layer

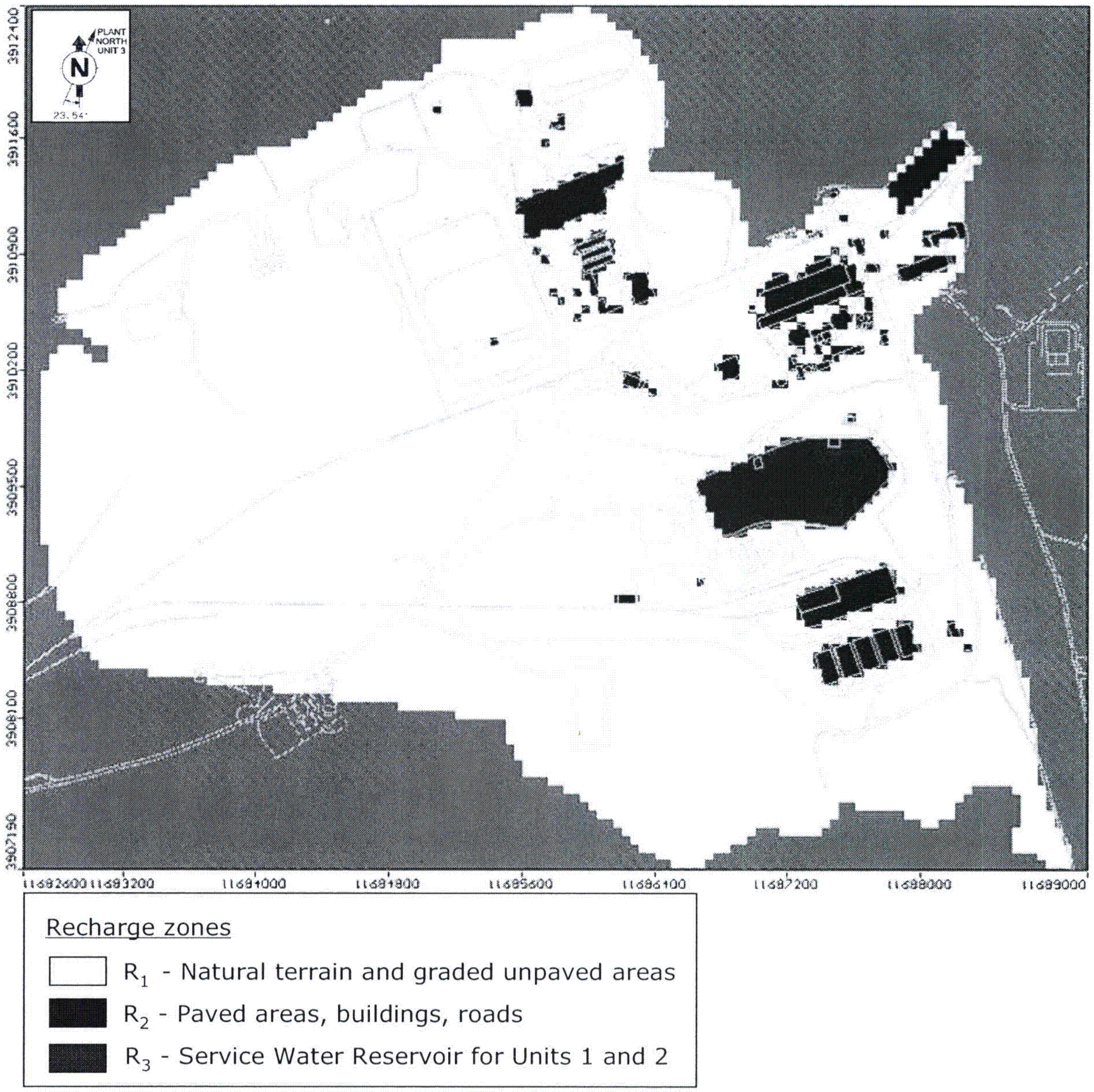


Figure 13. Groundwater recharge zones

Figure 14. Site geologic map (Figure 2.5-18, page 2-2-429 in Reference 1)

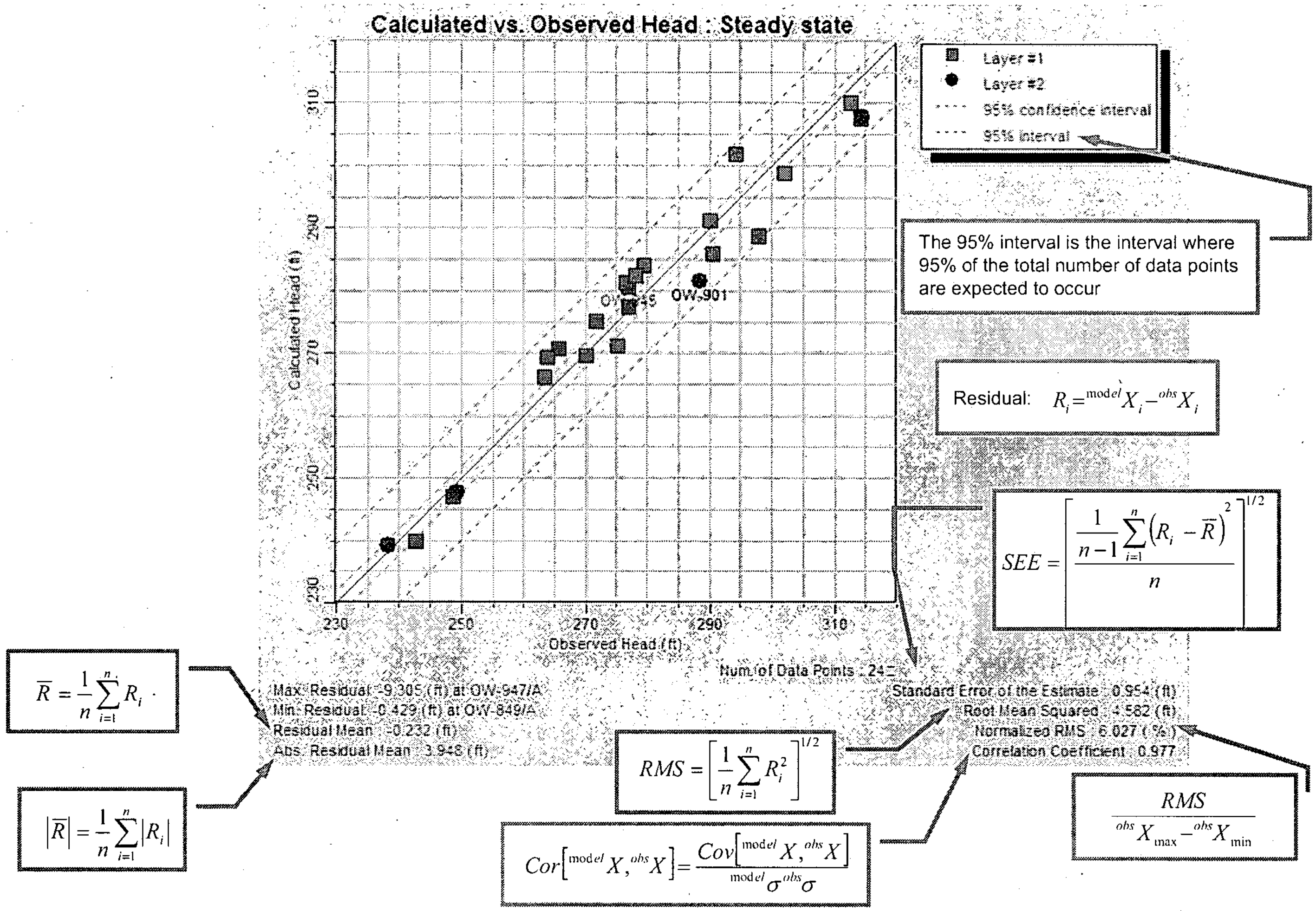


Figure 15. Calibration statistics available in Visual Modflow

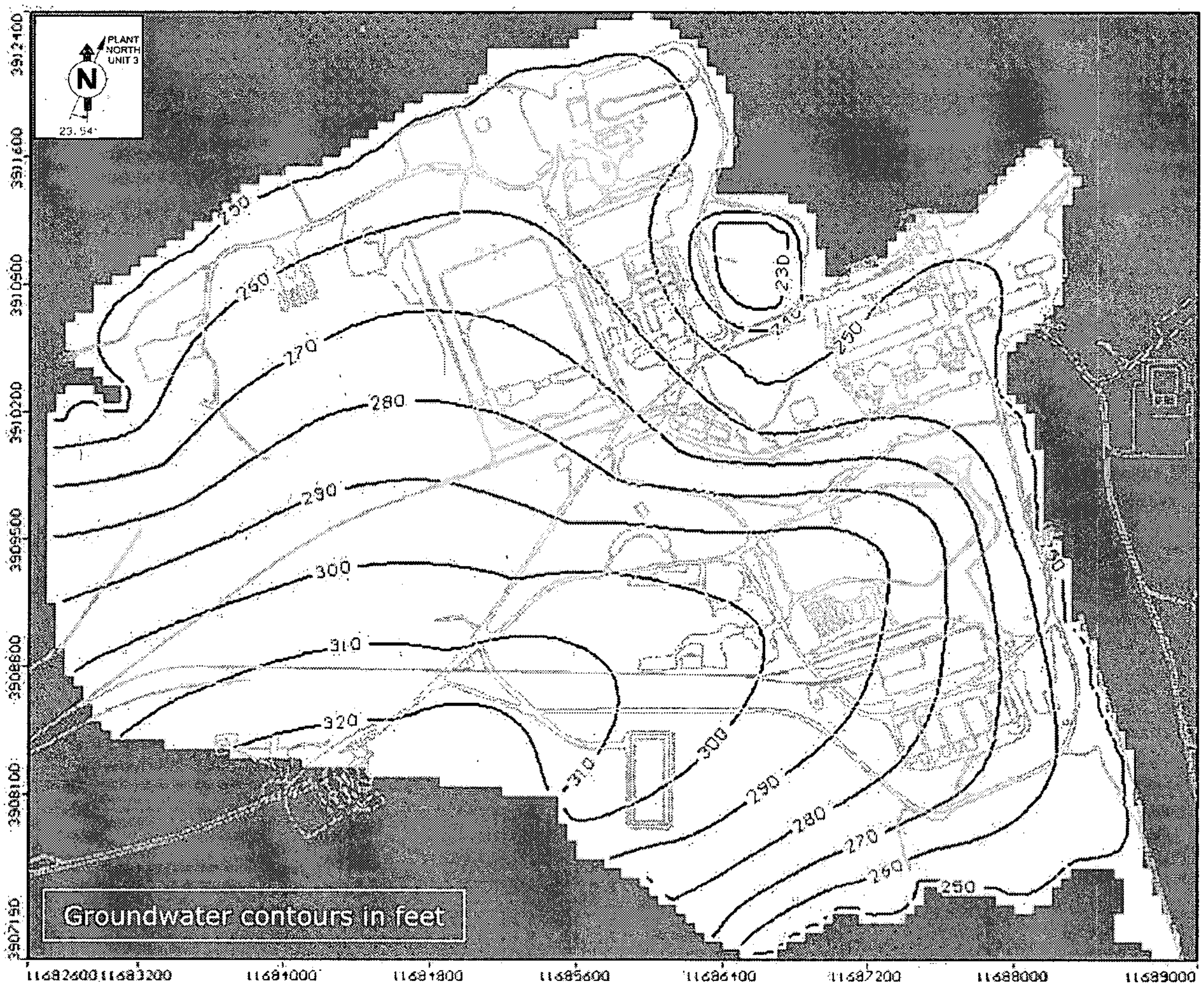


Figure 16. Computed heads with the calibrated model; layer 1

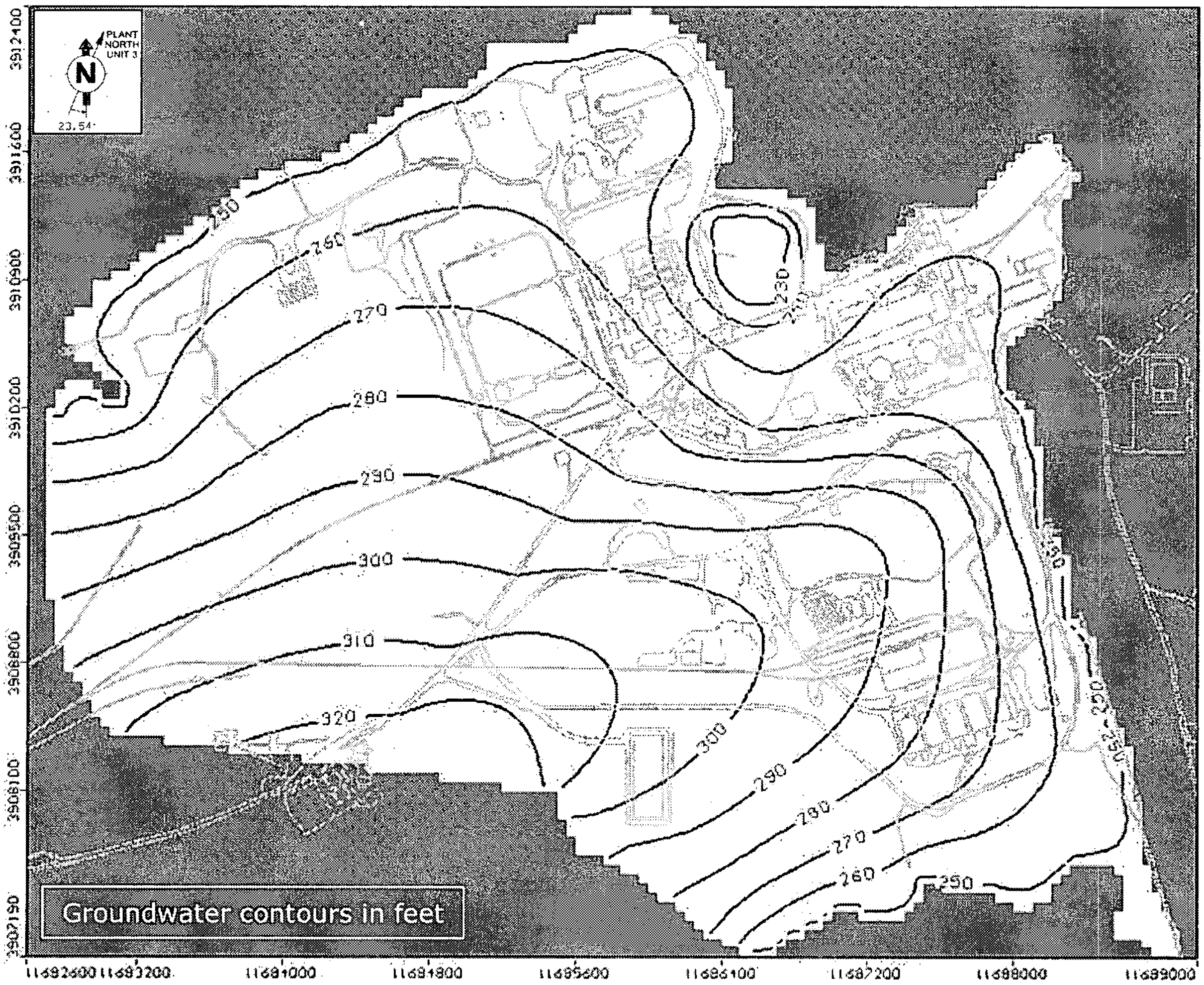


Figure 17. Computed heads with the calibrated model; layer 2

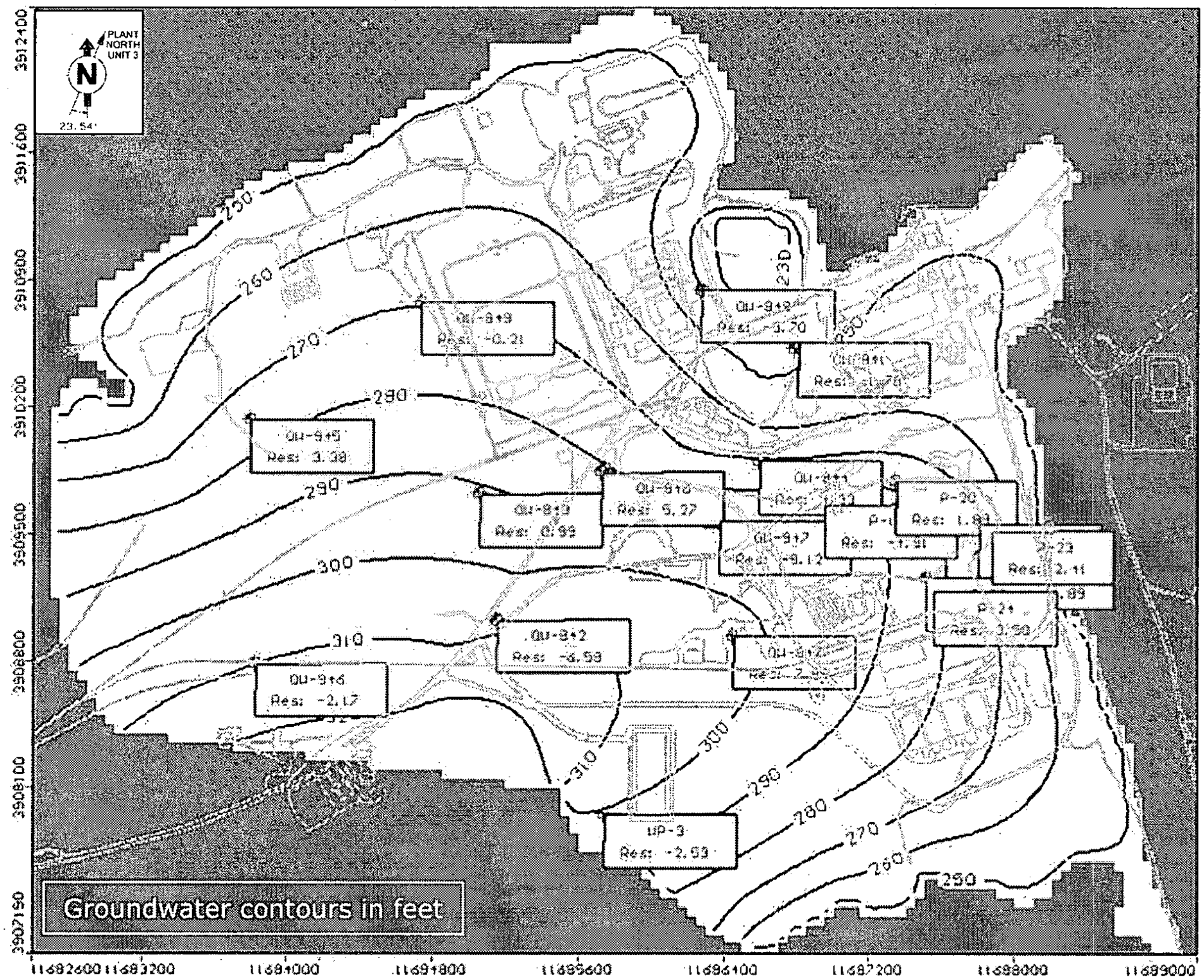


Figure 18. Head residuals for the calibrated model; layer 1

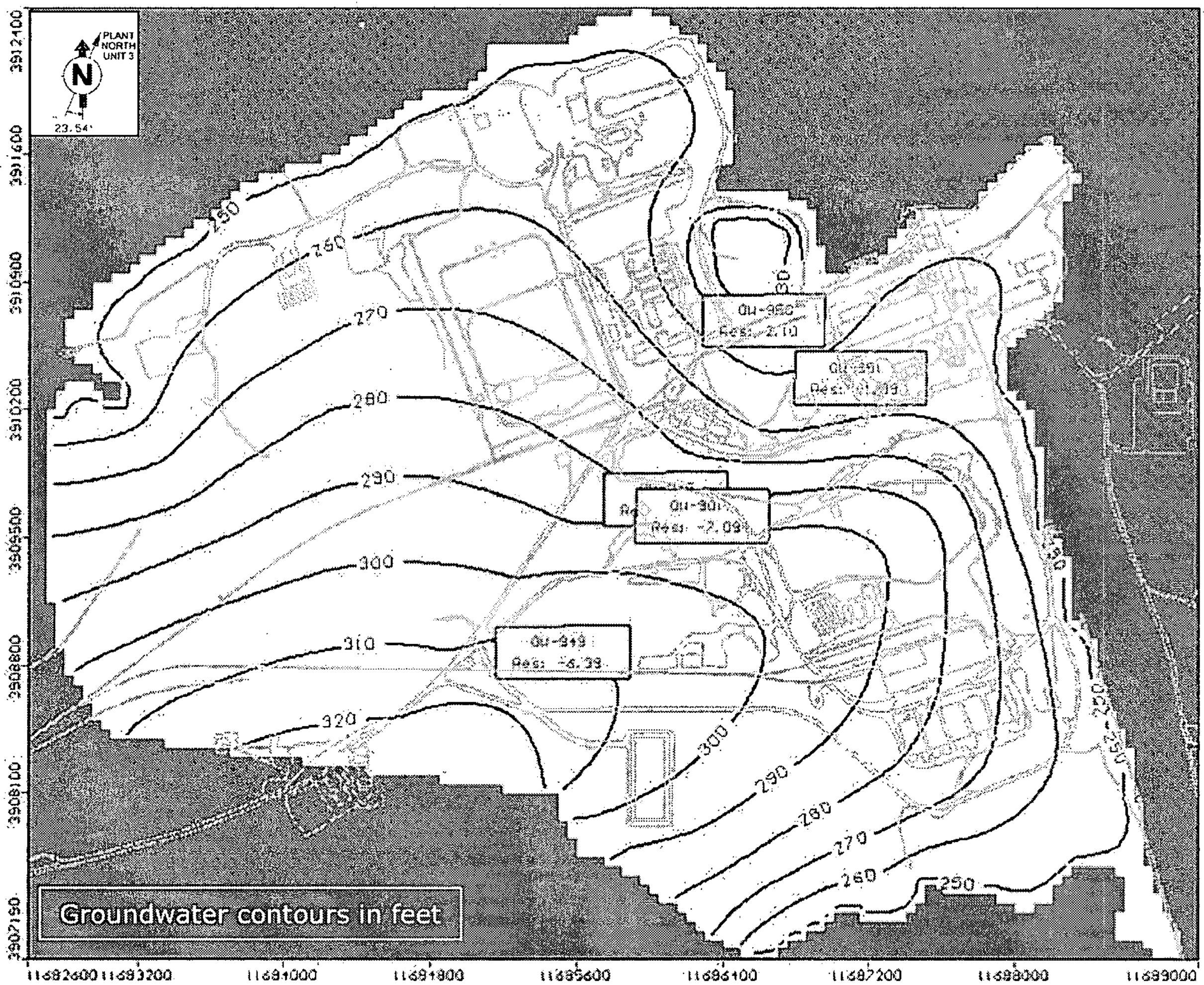


Figure 19. Head residuals for the calibrated model; layer 2

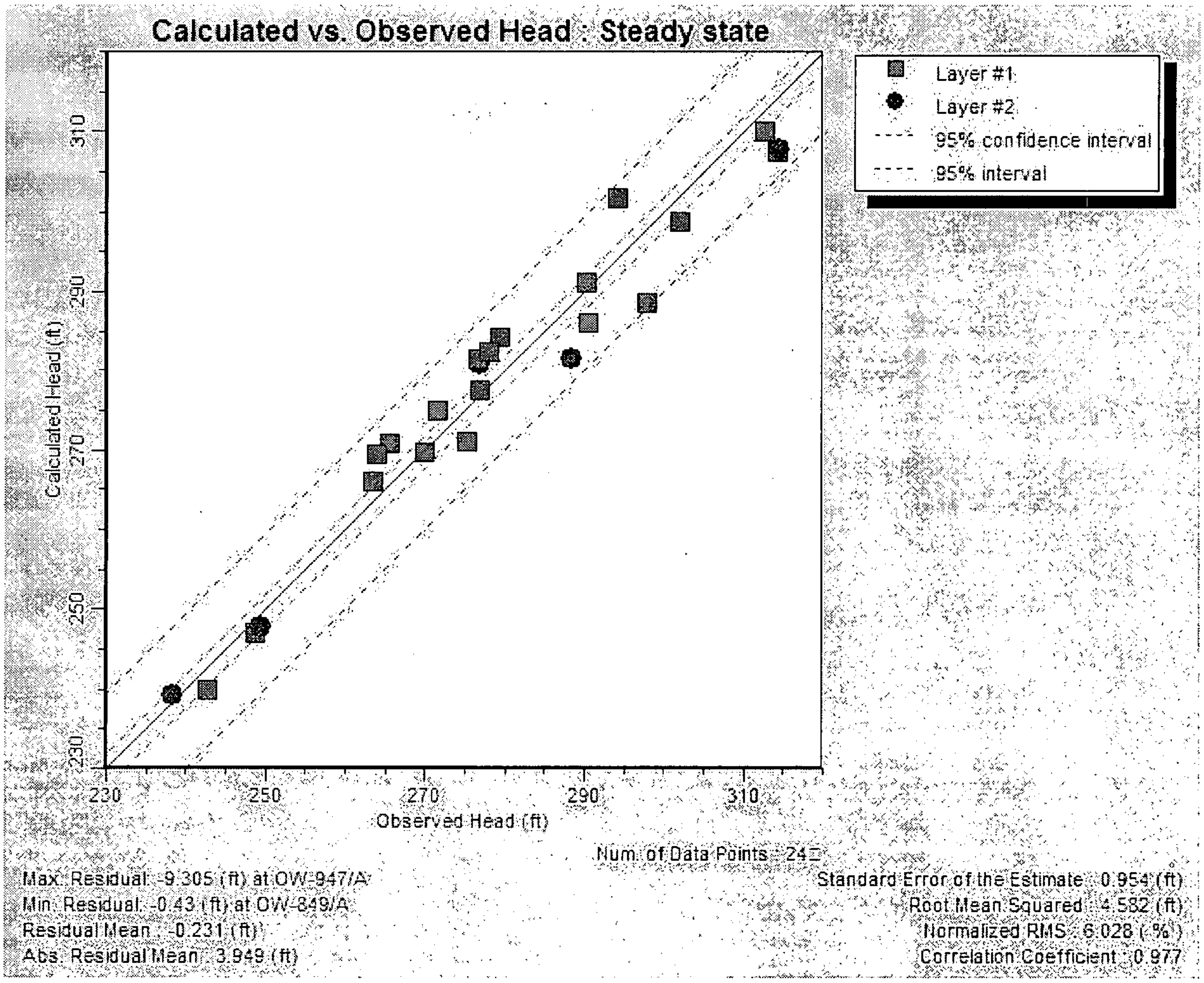


Figure 20. Basic statistics for the calibrated model

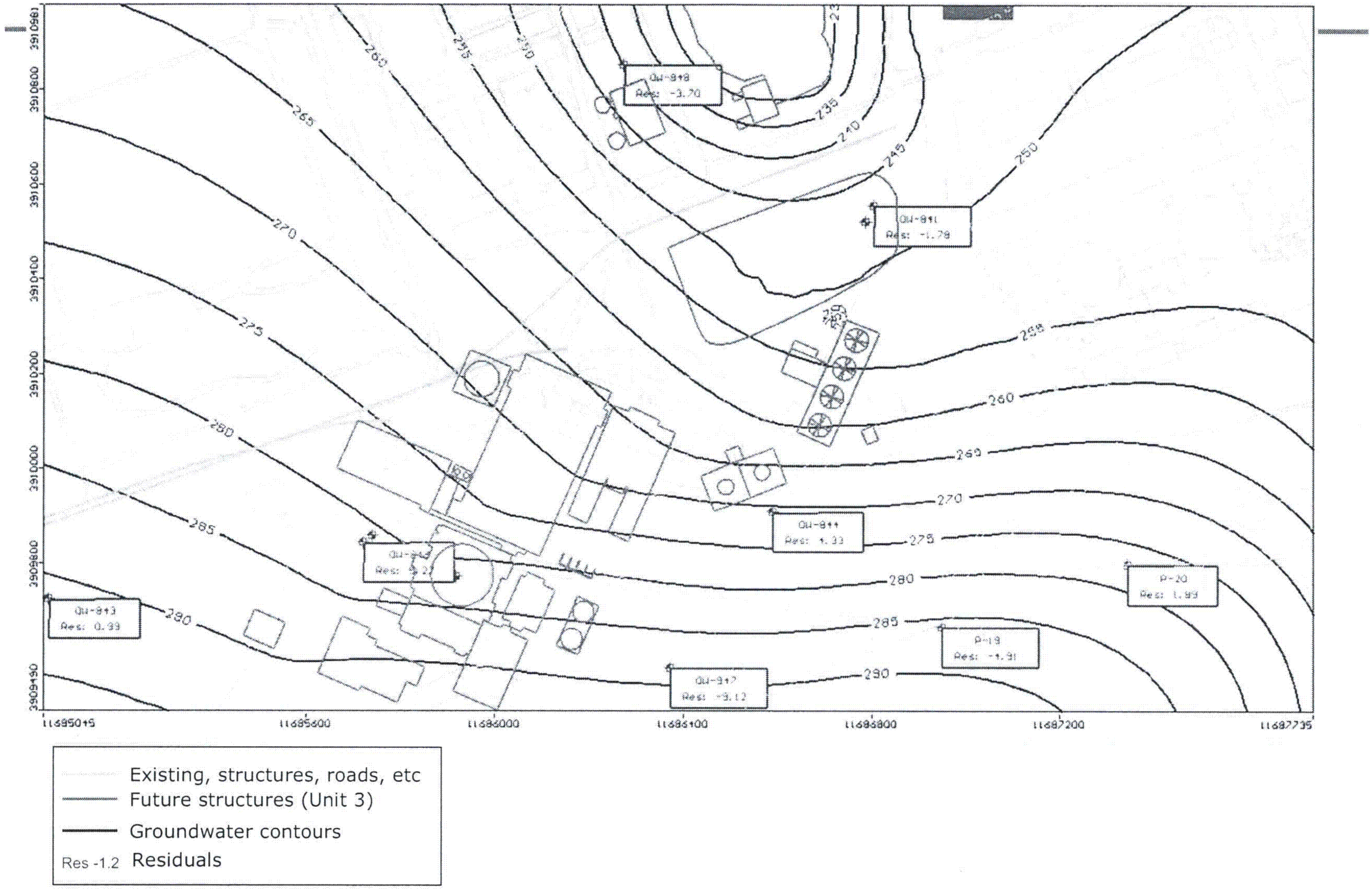


Figure 21. Simulated heads and residuals around Unit 3; layer 1

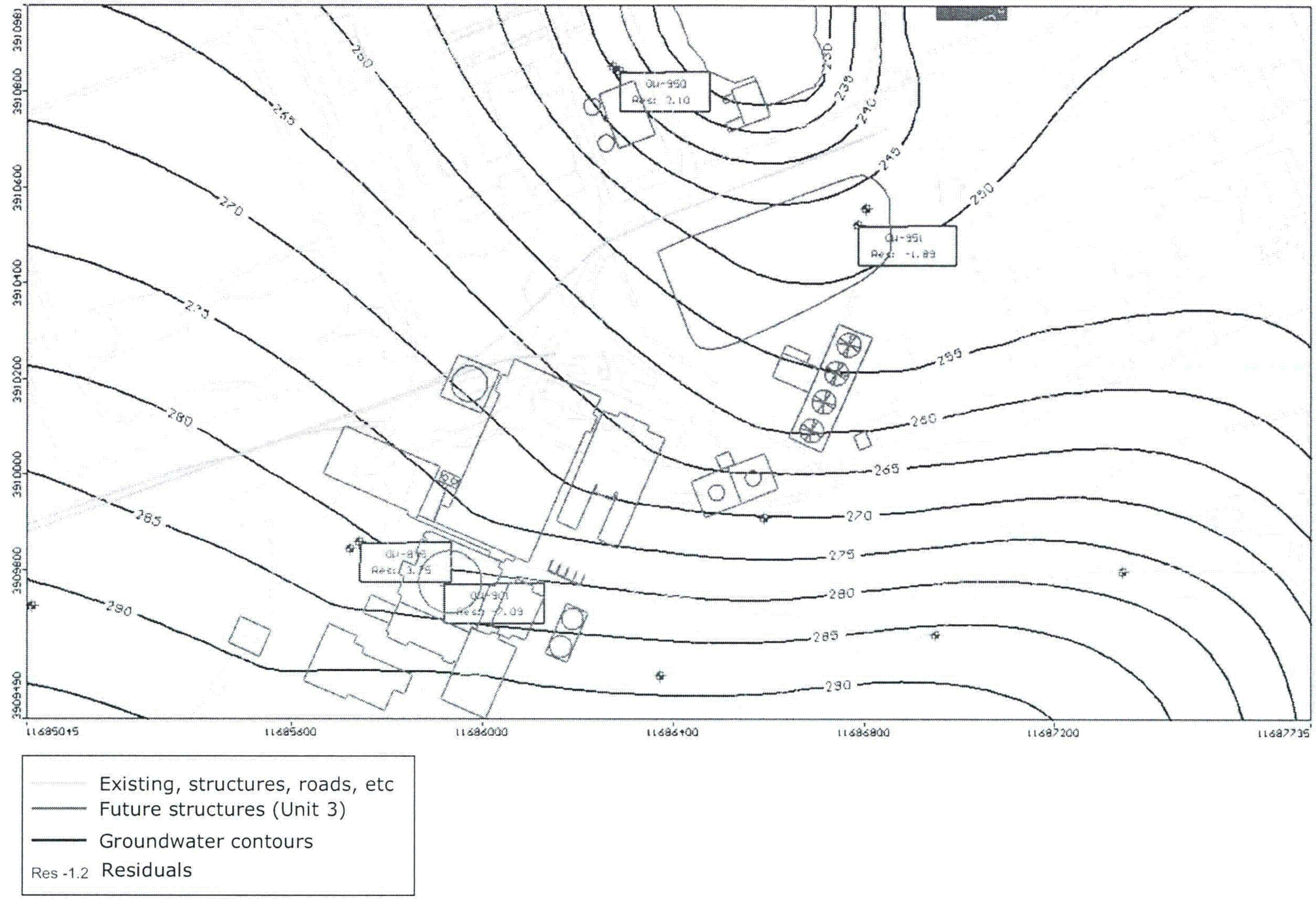


Figure 22. Simulated heads and residuals around Unit 3; layer 2

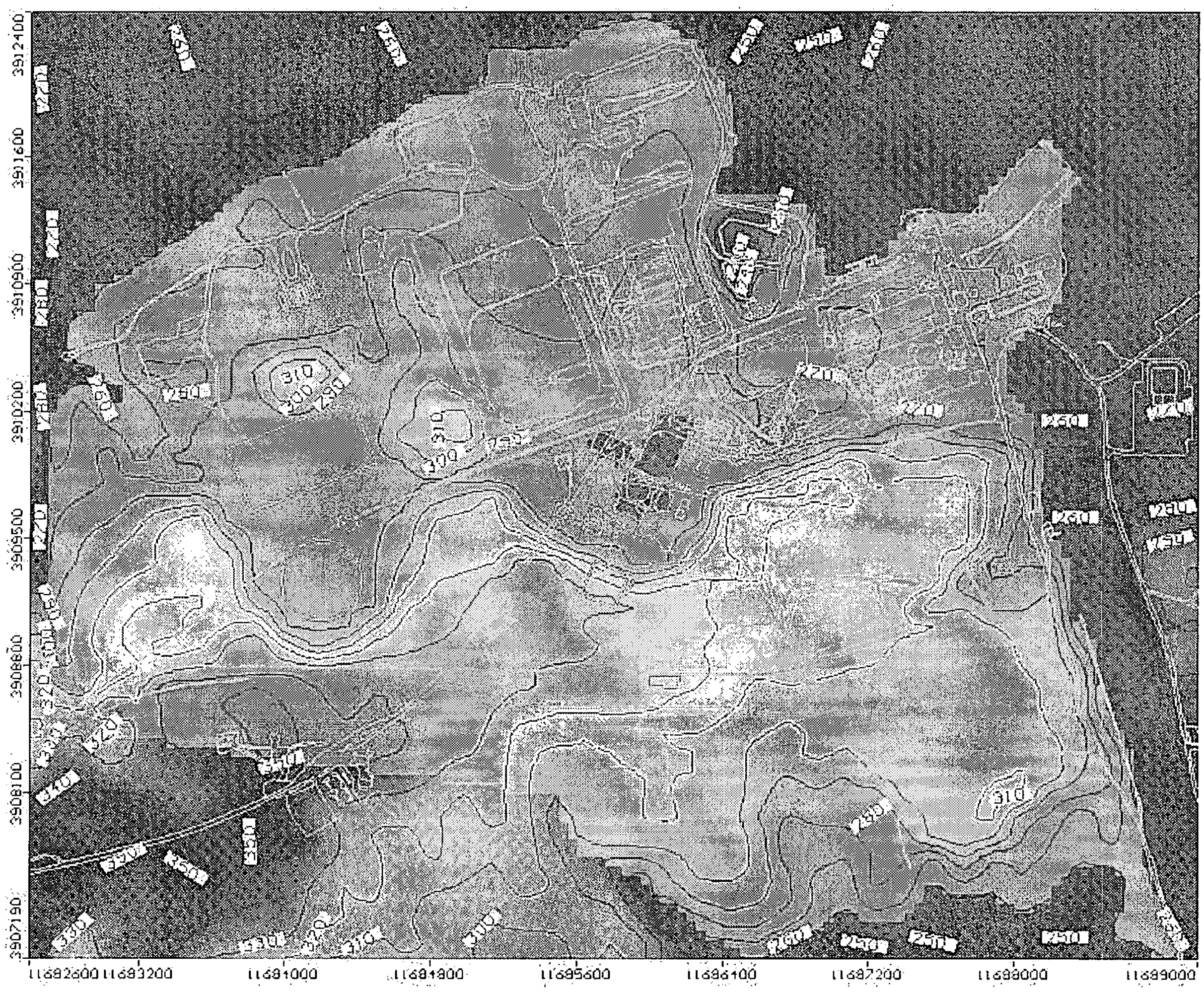
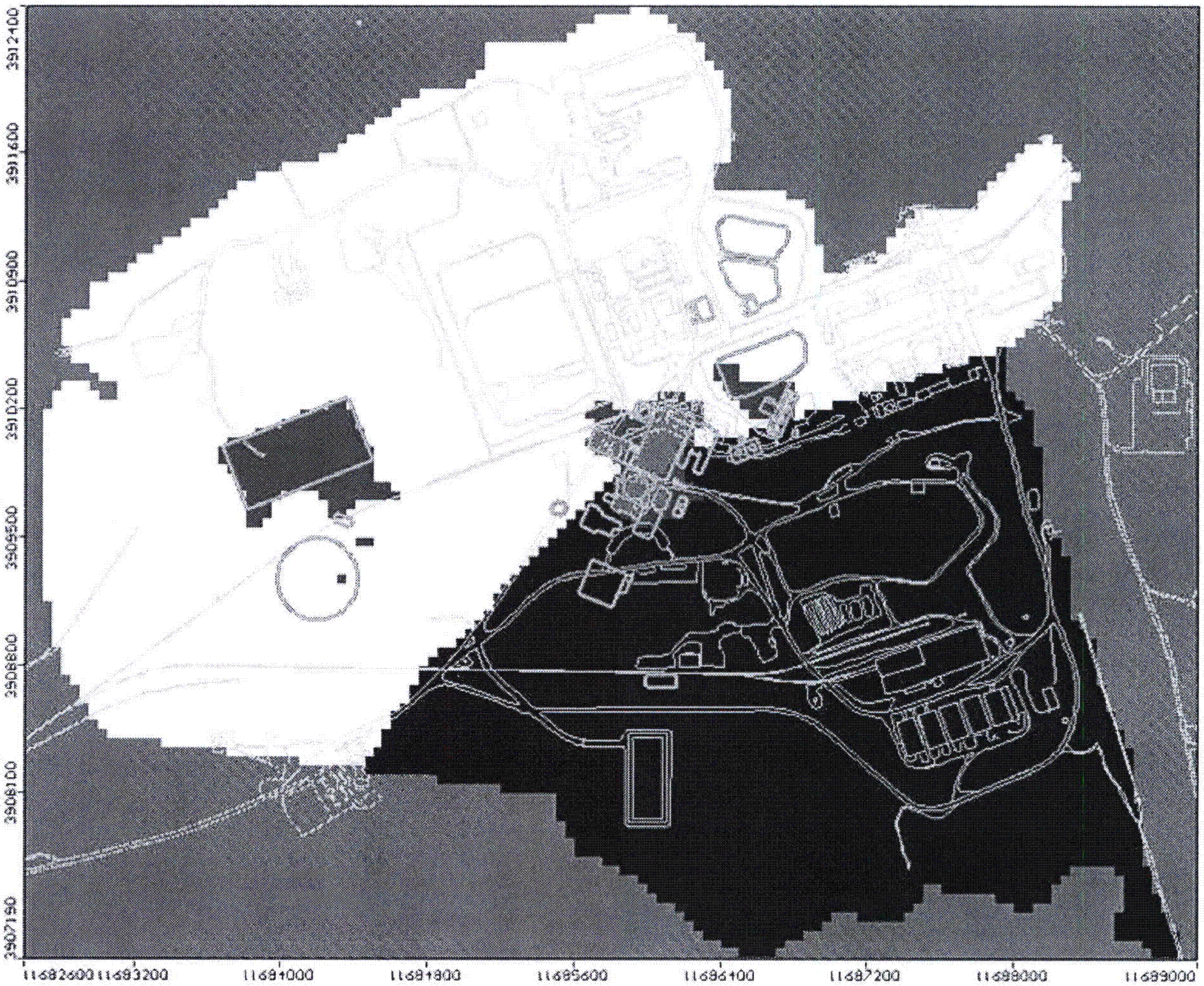


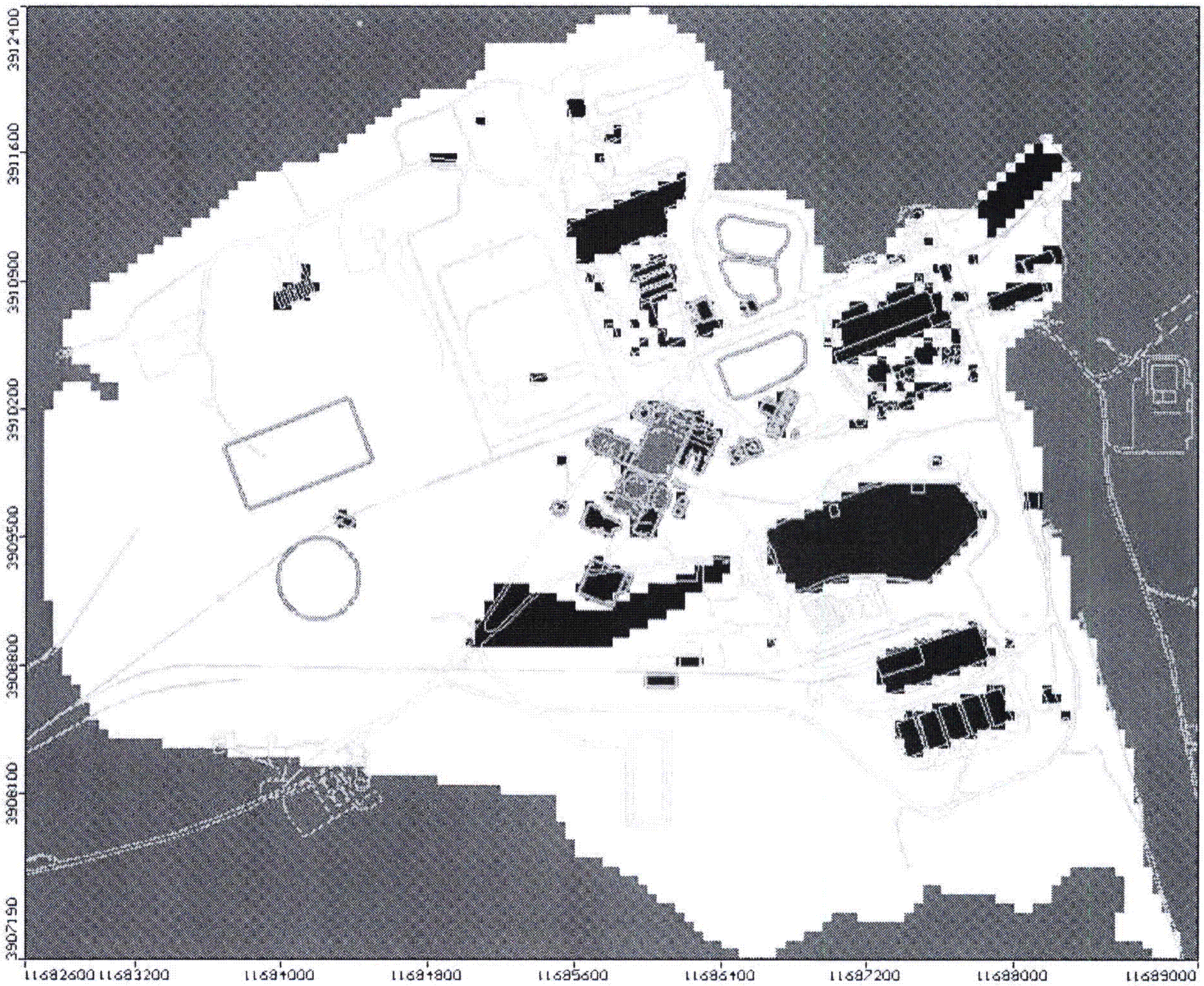
Figure 23. Modified topography after the construction of Unit 3



Legend

K_1 - Natural materials north of fault "a"	Existing structures, roads, etc
R_2 - Natural materials south of fault "a"	Proposes Unit 3 structures
R_3 – Construction fill	Inactive cells

Figure 24. Hydraulic conductivity zones for post Unit 3 construction conditions



<u>Legend</u>

- R_1 - Natural terrain and graded unpaved areas
- R_2 - Paved areas, buildings, roads
- R_3 - Service Water Reservoir for Units 1 and 2
- Existing structures, roads, etc
- Proposes Unit 3 structures
- Inactive cells

Figure 25. Groundwater recharge zones for post Unit 3 construction conditions

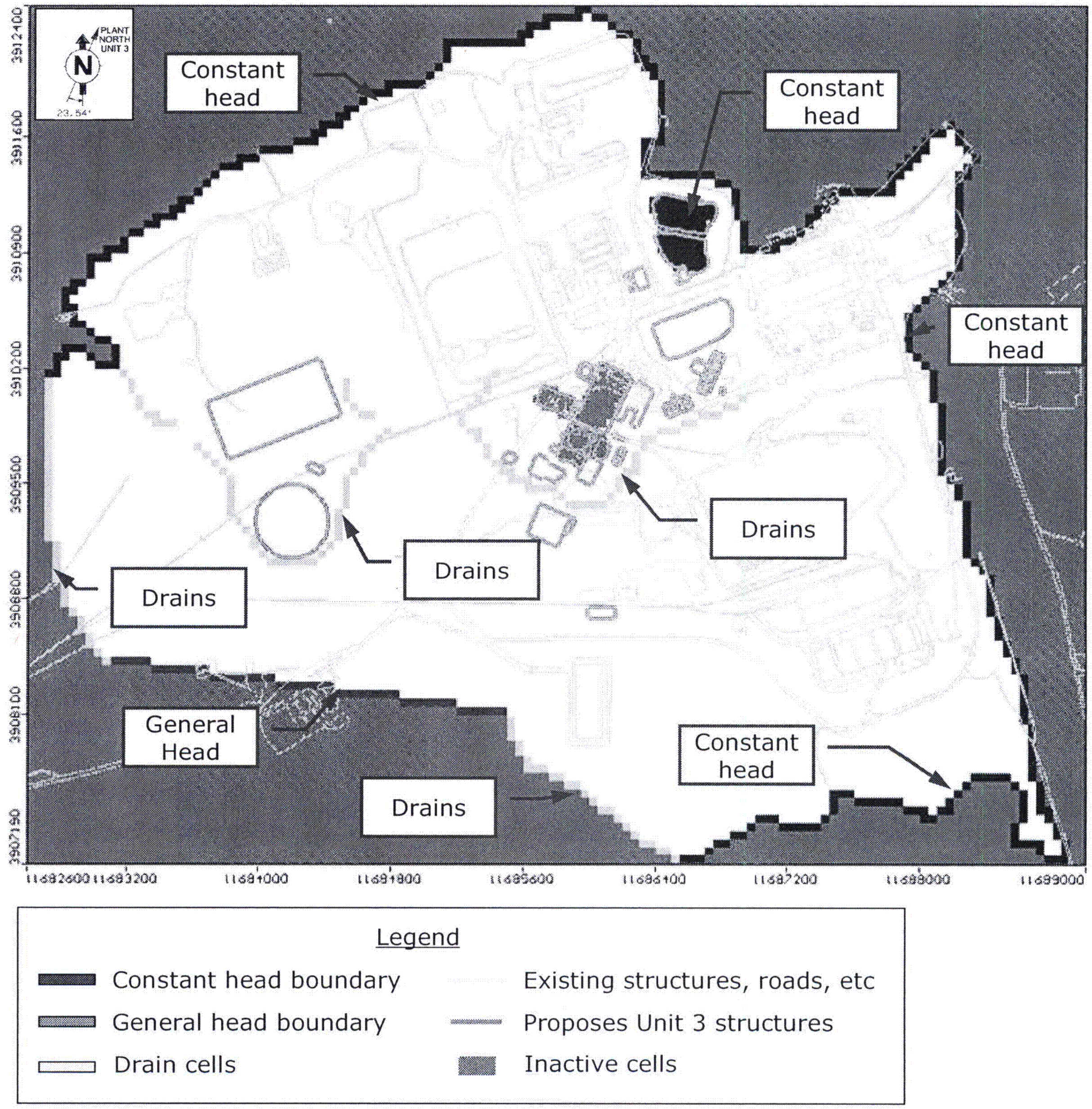


Figure 26. Boundary conditions for post Unit 3 construction conditions

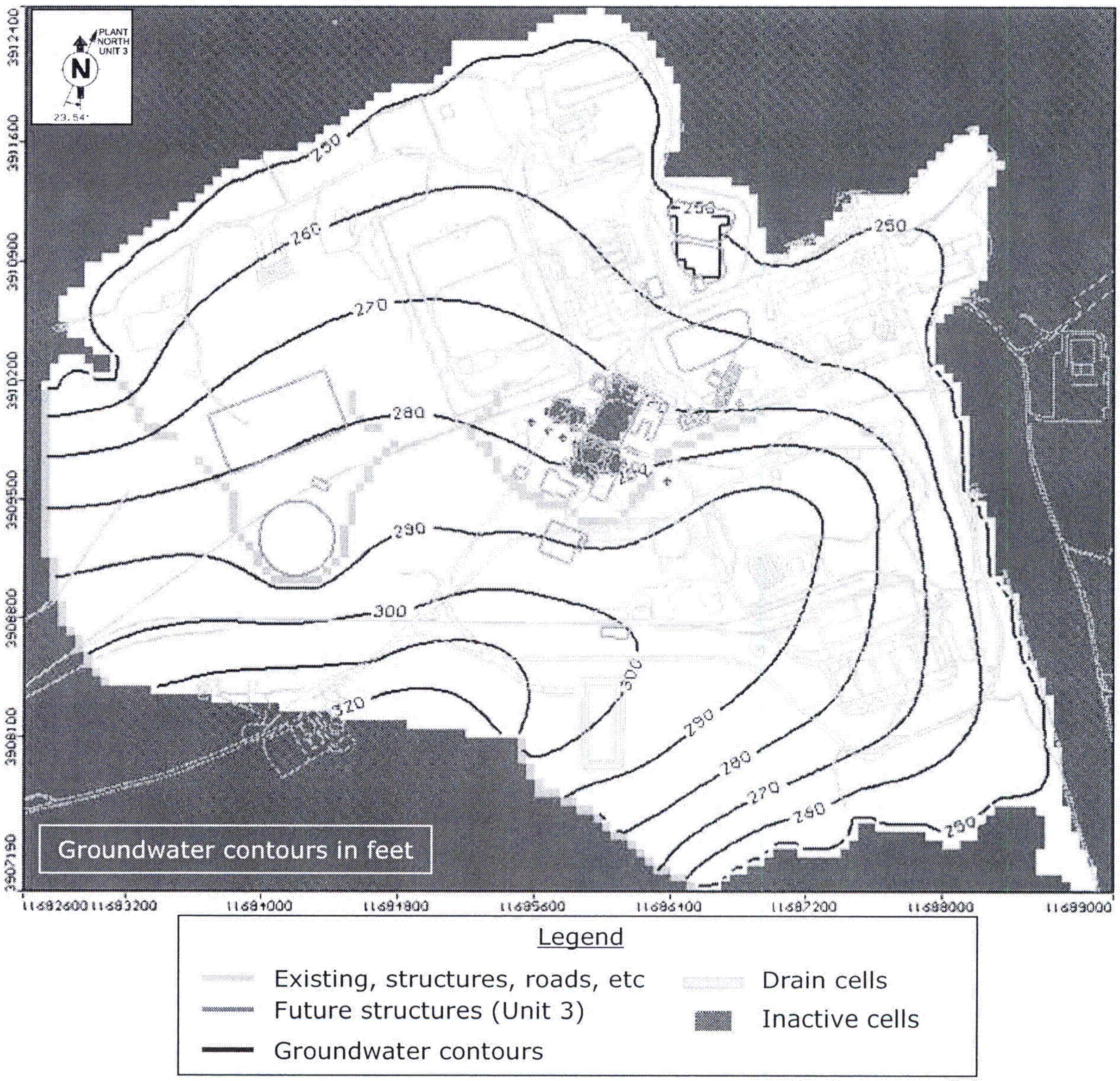


Figure 27. Post construction groundwater levels – layer 1

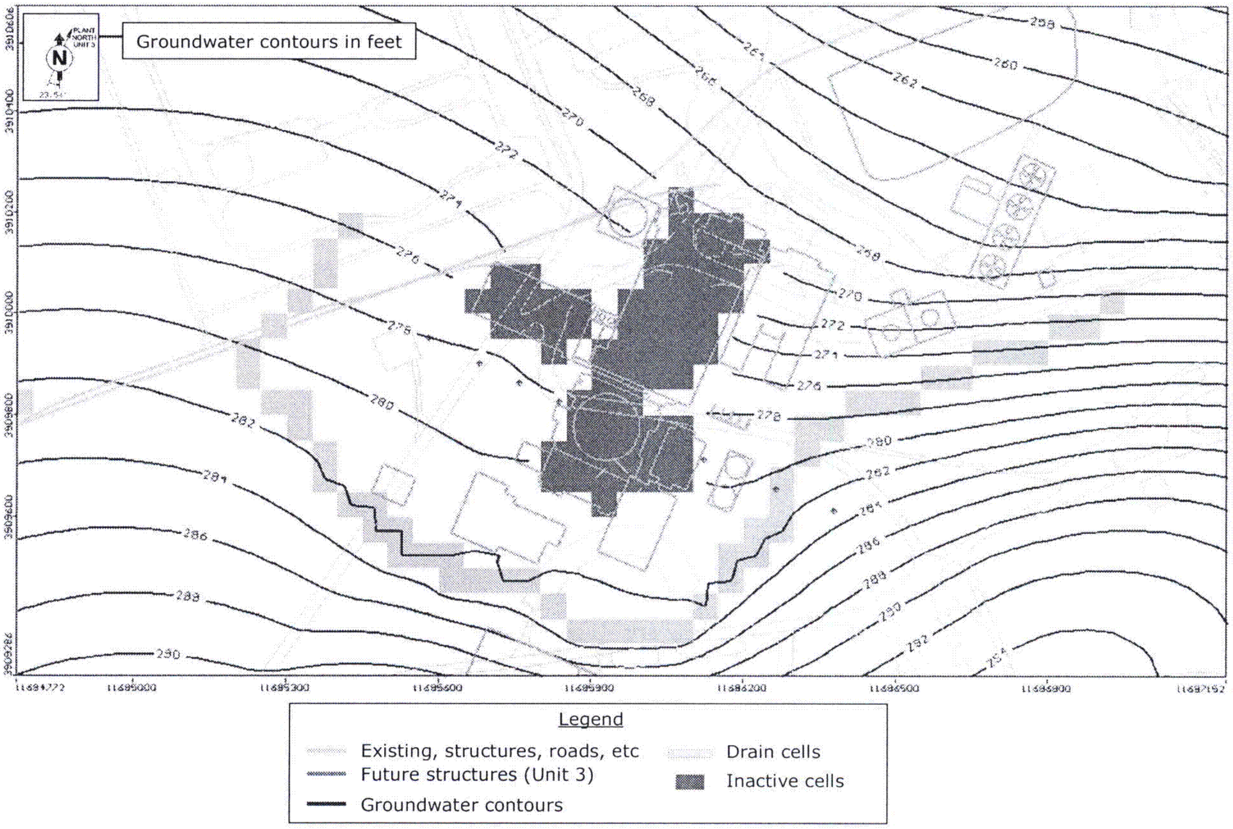


Figure 28. Post construction groundwater levels around the power block area – layer 1

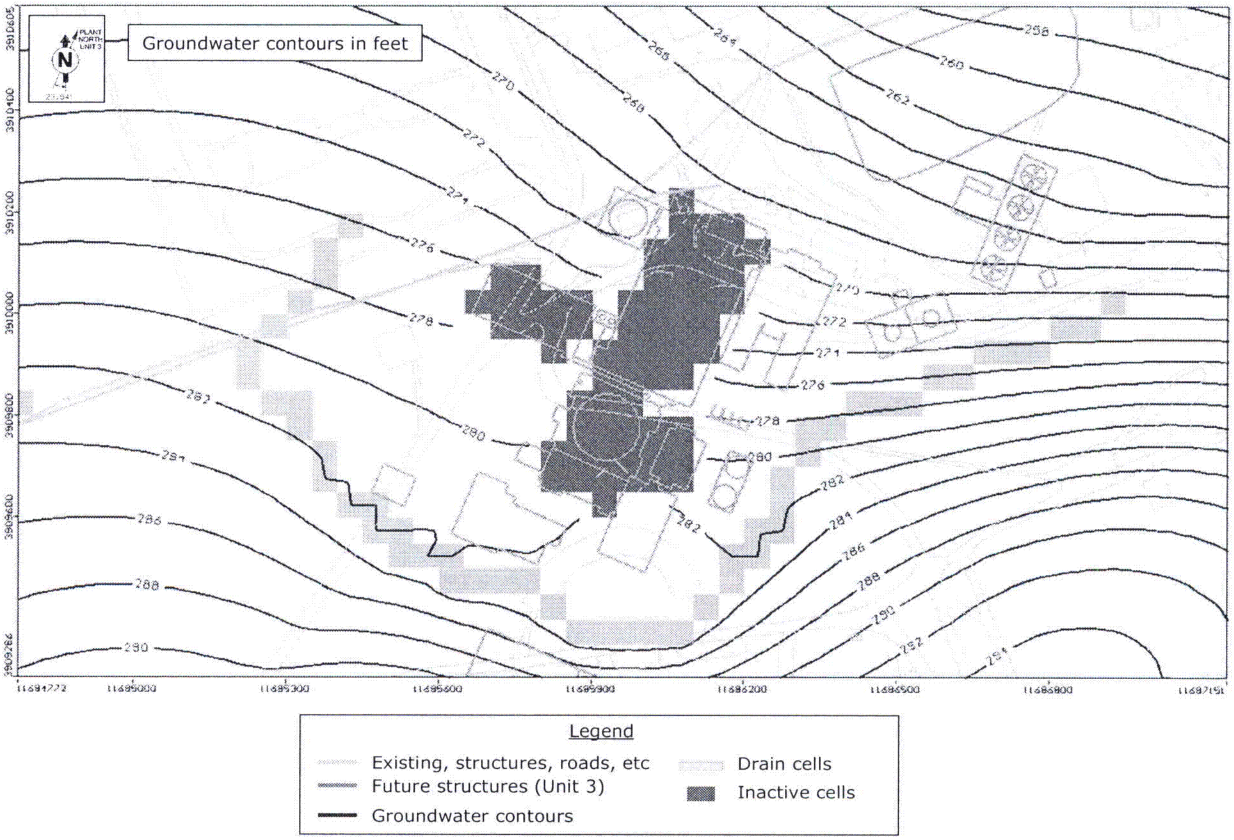


Figure 29. Post construction groundwater levels around the power block area assuming that the hydraulic conductivity of the fill is 10^{-4} cm/s – layer 1

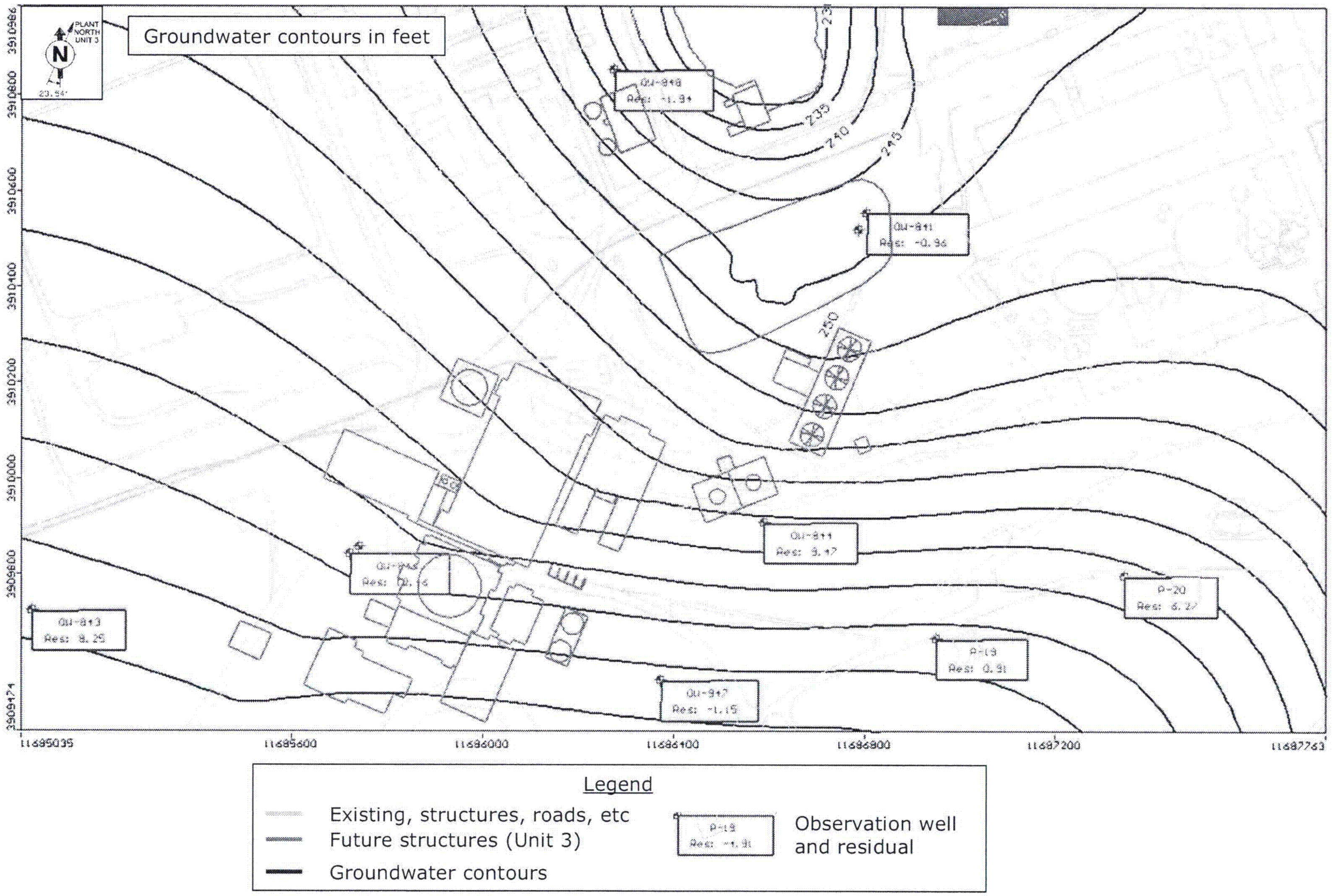


Figure 30. Simulated groundwater levels and residuals under existing conditions in model layer 1 assuming that the recharge over zone R_1 is 12.5 in/yr

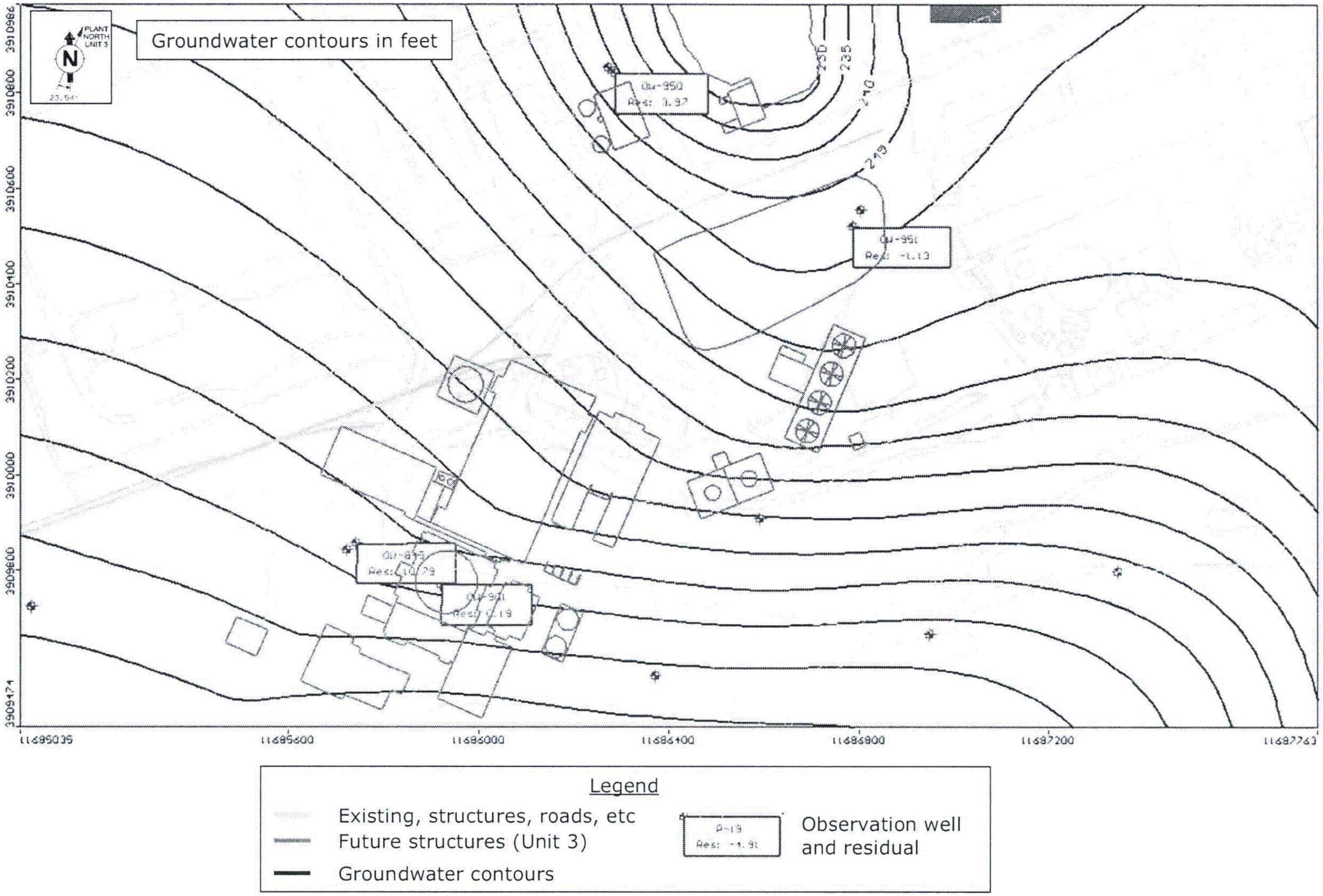


Figure 31. Simulated groundwater levels and residuals under existing conditions in model layer 2 assuming that the recharge over zone R_1 is 12.5 in/yr

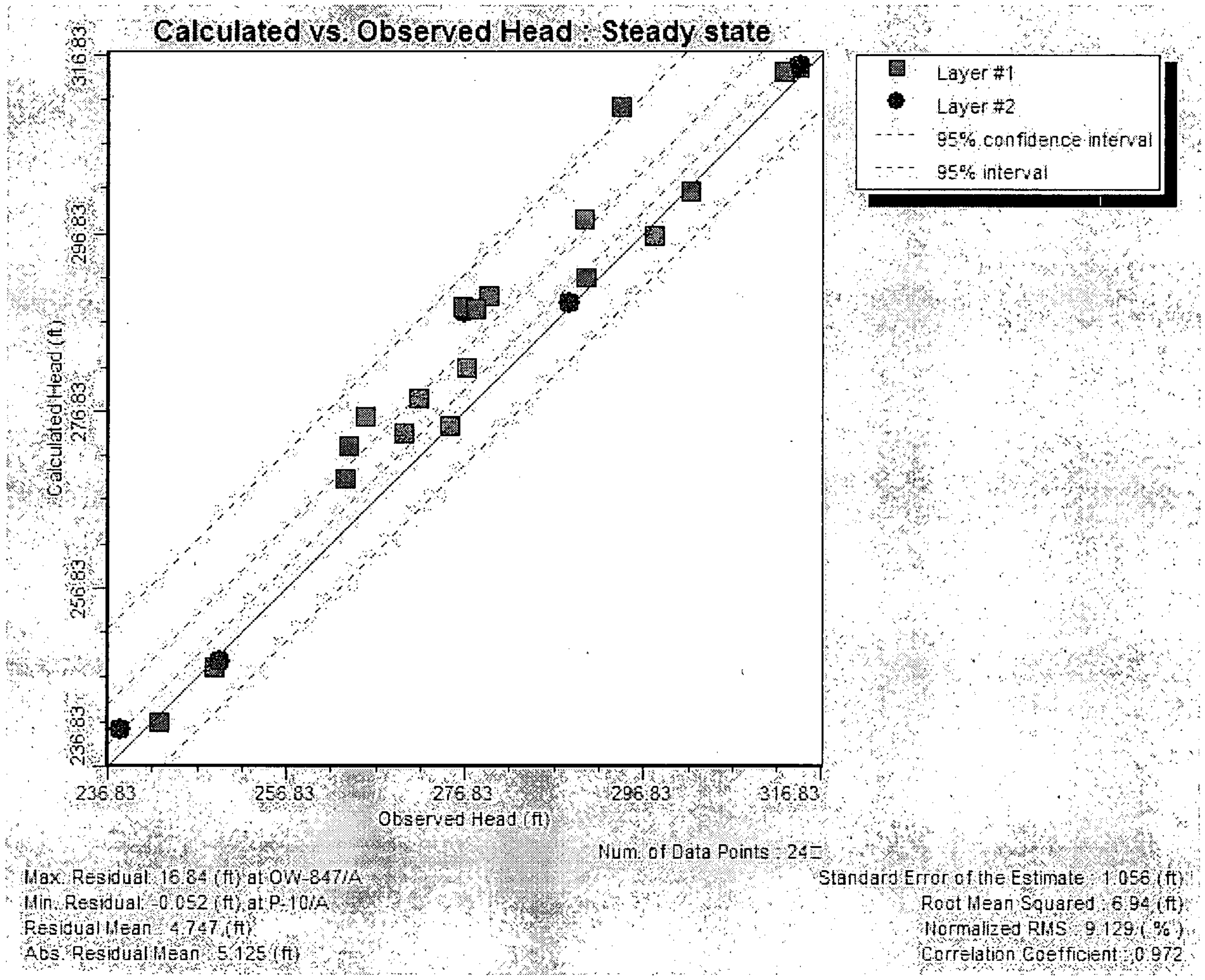


Figure 32. Computed vs. observed heads assuming that the recharge over zone R_1 is 12.5 in/yr

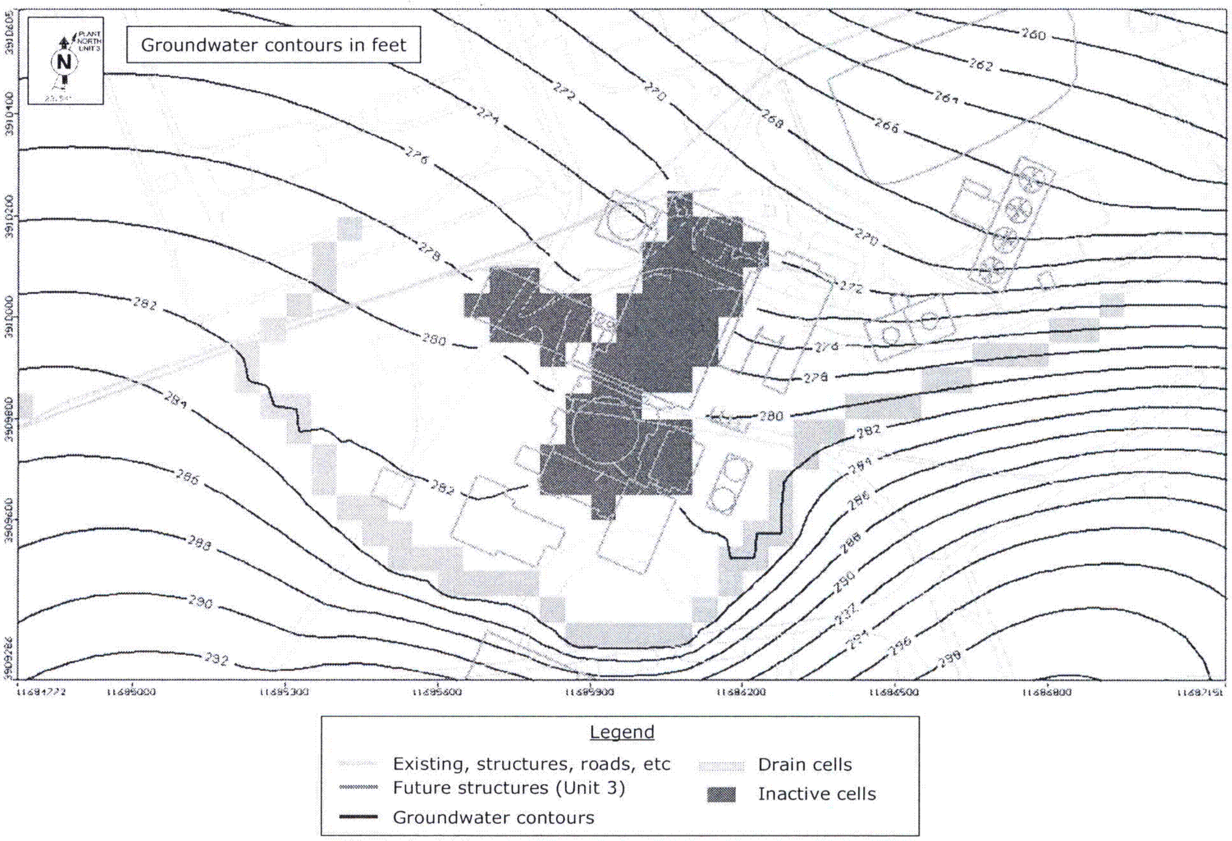


Figure 33. Predicted water table for post Unit 3 construction conditions assuming that the recharge over zone R_1 is 12.5 in/yr

ENCLOSURE 2

Response to NRC RAI Letter 024

RAI Question 12.02-4

NRC RAI 12.02-4

In Tier 2, Section 12.2.4 of the ESBWR DCD, GEH includes reference to COL information item 12.2-4-A, Other Contained Sources. Section 12.2 of the North Anna FSAR does include "STD SUP 12.2-1" which provides a supplemental section (Section 12.2.1.5, Other Contained Sources) to the FSAR which appears to address the proposed resolution of COL information item 12.2-4-A. However, neither Table 1.10-201 (Summary of FSAR Sections Where DCD COL Items Are Addressed), or Section 12.2 of the FSAR, address the COL Item12.2-4-A. Please correct this apparent discrepancy to the FSAR by modifying both Table 1.10-201 and Section 12.2 of the North Anna FSAR (and any other applicable sections of the FSAR) to address COL information item 12.2-4-A.

Dominion Response

Dominion agrees with the staff on the recommended resolution.

Dominion did not refer to COL Information Item 12.2-4-A in Revision 0 of the North Anna Unit 3 FSAR because it did not exist in ESBWR DCD Revision 4. Subsequent to Revision 0 of the FSAR in November 2007, GEH issued ESBWR DCD Revision 5 in June 2008 which contained COL Information Item 12.2-4-A.

The discrepancy will be addressed by revising FSAR Table 1.10-201 and Section 12.2 to address COL item 12.2-4-A.

Proposed COLA Revision

Revise FSAR Table 1.10-201 and Section 12.2 to address COL Information Item 12.2-4-A as shown in the attached markups.

Markup of North Anna COLA

The attached markup represents Dominion's good faith effort to show how the COLA will be revised in a future COLA submittal in response to the subject RAI. However, the same COLA content may be impacted by revisions to the ESBWR DCD, responses to other COLA RAIs, other COLA changes, plant design changes, editorial or typographical corrections, etc. As a result, the final COLA content that appears in a future submittal may be somewhat different than as presented herein.

NAPS SUP 1.10-1

Table 1.10-201 Summary of FSAR Sections Where DCD COL Items Are Addressed

Item No.	Subject/Description of Item	FSAR Section
11.5-2-A	Offsite Dose Calculation Manual	11.5.4.4, 11.5.4.5, and 11.5.5.8
11.5-3-A	Process and Effluent Monitoring Program	11.5, 11.5.4.6, and Table 11.5-201
11.5-4-A	Site Specific Offsite Dose Calculation	11.5.4.8
11.5-5-A	Instrument Sensitivities	11.5.4.9
12.1-1-A	Regulatory Guide 8.10	12BB
12.1-2-A	Regulatory Guide 1.8	12BB
12.1-3-A	Operational Considerations	12BB
12.1-4-A	Regulatory Guide 8.8	12BB
12.2-2-A	Airborne Effluents and Doses	12.2.2.1, 12.2.2.2, and Table 2.0-201
12.2-3-A	Liquid Effluents and Doses	12.2.2.4
12.2-4-A	Other Contained Sources	12.2.1.5
12.3-2-A	Operational Considerations	12.3.4
12.3-3-A	Controlled Access	12.3.1.3
12.5-1-A	Equipment, Instrumentation, and Facilities	12BB
12.5-2-A	Compliance with 10 CFR Part 50.34(f)(2)(xxvii) and NUREG-0737 Item III.D.3.3	12BB
12.5-3-A	Radiation Protection Program	12BB
13.1-1-A	Organizational Structure	9.5.1.15.3, 13.1.1 through 13.1.3, and Appendix 13AA
13.2-1-A	Reactor Operator Training	13.2.1 and 13BB
13.2-2-A	Training for Non-Licensed Plant Staff	13.2.2 and 13BB
13.3-1-A	Identification of OSC and Communication Interfaces with Control Room and TSC	13.3 and COLA Part 5, Sections II.F and II.H
13.3-2-A	Identification of EOF and Communication Interfaces With Control Room and TSC	13.3 and COLA Part 5, Sections II.F and II.H
13.3-3-A	Decontamination Facilities	13.3 and COLA Part 5, Section II.J
13.4-1-A	Operation Programs	13.4

12.1-4-A **Regulatory Guide 8.8**

STD COL 12.1-4-A

This COL item is addressed in Section 12.1.1.3.1 and Appendix 12BB.

12.2 Plant Sources

This section of the referenced DCD is incorporated by reference with the following departures and/or supplements.

~~STD SUP 12.2-1~~
STD COL 12.2-4-A

12.2.1.5 **Other Contained Sources**

In addition to the contained sources identified above, additional contained sources which contain by-product, source, or special nuclear materials may be maintained on site. These contained sources are typically used as calibration or radiography sources. These sources are not part of the permanent plant design, and their control and use are governed by plant procedures. The procedures consider the guidance provided in RG 8.8 to ensure that occupational doses from the control and use of the sources are as low as is reasonably achievable (ALARA).

Various types and quantities of radioactive sources are employed to calibrate the process and effluent radiation monitors, the area radiation monitors, and portable and laboratory radiation detectors. Check sources that are integral to the area, process, and effluent monitors consist of small quantities of by-product material and do not require special handling, storage, or use procedures for radiation protection purposes. The same consideration applies to solid and liquid radionuclide sources of exempt quantities or concentrations which are used to calibrate or check the portable and laboratory radiation measurement instruments.

Instrument calibrators are normally used for calibrating gamma dose rate instrumentation. These may be self-contained, heavily shielded, multiple source calibrators. Beta and alpha radiation sources are also available for instrument calibration. Calibration sources are traceable to the National Institute of Standards and Technology, or equivalent.

Radiography sources are surveyed upon entry to the site. Radiation protection personnel maintain copies of the most recent leak test records for owner-controlled sources. Contractor radiography personnel provide copies of the most recent leak test records upon radiation protection personnel request. Radiography is conducted in accordance with approved procedures.

Although not every radionuclide is bounded, the total liquid effluent release activity of Unit 3 is less than the total composite release activity presented in the ESP-ER.

Table 12.2-19bR shows the total activity concentrations at the site release point for the nuclides in radioactive liquid effluent for Units 1, 2, and 3. For every nuclide, the maximum activity concentration is equal to or less than the corresponding value in ESP-ER Table 5.4-6.

12.2.2.4.7 **Comparison of ESPA to Unit 3 Liquid Effluent Doses**

As described in Section 12.2.2.4, the calculated radioactive liquid effluent doses for Unit 3 are provided in Table 12.2-20bR.

The radioactive liquid effluent doses for the ESPA are included in ESP-ER Table 5.4-8. The results from that table are reproduced in Table 12.2-20bR. The dose for each liquid radioactive effluent pathway for Unit 3 is less than the corresponding estimate in the ESP-ER. Table 12.2-202 summarizes the annual total body and bone doses to the MEI and shows that the Unit 3 doses are lower than those calculated and presented in ESP-ER Table 5.4-10.

As indicated in Tables 12.2-203 and 12.2-204, the annual total site doses to the MEI and the population within 50 miles of Unit 3 are lower than those calculated and presented in ESP-ER.

12.2.4 COL Information

12.2-2-A Airborne Effluents and Doses

NAPS COL 12.2-2-A

This COL item is addressed in Sections 12.2.2.1, 12.2.2.2, and Table 2.0-201.

12.2-3-A Liquid Effluents and Doses

NAPS COL 12.2-3-A

This COL item is addressed in Section 12.2.2.4.

12.2-4-A Other Contained Sources

STD COL 12.2-4-A

This COL item is addressed in Section 12.2.1.5.

12.2.5 References

12.2-201 USNRC, "Safety Evaluation Report for an Early Site Permit (ESP) at the North Anna ESP Site, NUREG-1835 Supplement 1, November 2006

ENCLOSURE 3

Response to NRC RAI Letter 024

RAI Question 12.02-5

NRC RAI 12.02-5

FSAR Section 12.2.1.5, "Other Contained Sources," (STD SUP 12.2-1) states that the control and use of the additional contained by-product, source, or special nuclear material sources which are not part of the permanent plant design and which are not listed in the ESBWR DCD will be governed by plant procedures.

a) State whether these procedures will be part of the Radiation Protection Program, as described in Section 12.5 of the North Anna COL. Additionally, state whether these materials will be controlled under the procedures described in Section 12.5.4.10 (Radioactive Material Control) of NEI 07-03.

b) 10 CFR 20.1801 requires licensees to secure from unauthorized removal or access licensed materials that are stored in controlled or unrestricted areas. Describe how the additional contained sources described in STD SUP 12.2-1 (response to COL Information Item 12.2-4-A) will be secured in accordance with 10 CFR 20.1801. Describe how the materials will be tracked.

c) STD SUP 12.2-1 (response to COL Information Item 12.2-4-A) of the COL application states that "Radiography is conducted in accordance with approved procedures". Describe what is meant by approved procedures.

Dominion Response

Radiation Protection Program Procedures
North Anna Unit 3 FSAR Section 12.5, "Operational Radiation Protection Program," incorporates by reference the DCD Section 12.5. Each of the three COL Information Items in that section is addressed by Appendix 12BB of the FSAR. FSAR Appendix 12BB, "Radiation Protection," incorporates by reference NEI 07-03, "Generic FSAR Guidance for Radiation Protection Program Description." Therefore, NEI 07-03 is the Radiation Protection Plan for North Anna Unit 3. NEI 07-03, Section 12.5, states, "(a) radiation protection program is developed, documented and implemented through plant procedures...."

Radiation protection plant procedures, including those described in this RAI, are part of the North Anna Unit 3 Radiation Protection Program. NEI 07-03, Section 12.5, part 1.d., "Procedures," states that procedures will be established, implemented and maintained sufficient to maintain adequate control over the receipt, storage, and use of radioactive materials..." The procedures described in Section 12.5.4 (including 12.5.4.10) will control the use of the additional contained by-product, source, or special nuclear material sources. Specifically, NEI 07-03, Section 12.5.4 states, "(r)adiation protection procedures are established, implemented and maintained sufficient to provide adequate control over the receipt, possession, use, transfer, and disposal of byproduct, source, and special nuclear material..."

Securing and Tracking Contained Sources
NEI 07-03 has been incorporated by reference in the FSAR and thus the NEI 07-03 requirements for secure storage and tracking of contained sources are FSAR

requirements. NEI 07-03, Section 12.5.3.1, "Facilities," states that, "a radioactive materials storage area(s) is established, as needed and in accordance with 10 CFR 20.1801..." In addition, Section 12.5.4.10, "Radioactive Material Control," states that, "(p)rocedures are established, implemented and maintained that assure compliance with the requirements of 10 CFR 20.1801....to assure positive control over licensed radioactive material..."

Approved Procedure
An approved procedure is one that has been reviewed and approved by proper cognizant management personnel and issued for use in accordance with governing administrative controls.

Proposed COLA Revision

None.

ENCLOSURE 4

Response to NRC RAI Letter 024

RAI Question 12.02-6

NRC RAI 12.02-6

FSAR Section 12.2.1.5, "Other Contained Sources," (STD SUP 12.2-1) states that additional contained sources are "typically used as calibration or radiography sources." State any uses besides calibration or radiography that these sources will be used for. If there will be no additional uses, reword the previous statement to show these additional sources will only be used for calibration and radiography sources.

Dominion Response

An additional use for contained sources is as a check source. FSAR Section 12.2.1.5 states that, "(t)he same consideration applies to solid and liquid radionuclide sources of exempt quantities or concentrations which are used to calibrate or check the portable and laboratory radiation measurement instruments." Based on ANSI N323A-1997, a check source is a radiation source, not necessarily calibrated, used to confirm the continuing satisfactory operation of an instrument.

The section will be revised to specify that contained sources are used as calibration, check or radiography sources.

Proposed COLA Revision

FSAR Section 12.2.1.5 will be revised as shown in the attached markup.

Markup of North Anna COLA

The attached markup represents Dominion's good faith effort to show how the COLA will be revised in a future COLA submittal in response to the subject RAI. However, the same COLA content may be impacted by revisions to the ESBWR DCD, responses to other COLA RAIs, other COLA changes, plant design changes, editorial or typographical corrections, etc. As a result, the final COLA content that appears in a future submittal may be somewhat different than as presented herein.

12.1-4-A **Regulatory Guide 8.8**

STD COL 12.1-4-A This COL item is addressed in Section 12.1.1.3.1 and Appendix 12BB.

12.2 Plant Sources

This section of the referenced DCD is incorporated by reference with the following departures and/or supplements.

~~**STD SUP 12.2-1**~~
STD COL 12.2-4-A

12.2.1.5 **Other Contained Sources**

In addition to the contained sources identified above, additional contained sources which contain by-product, source, or special nuclear materials may be maintained on site. These contained sources are ~~typically~~ used as calibration, check, or radiography sources. These sources are not part of the permanent plant design, and their control and use are governed by plant procedures. The procedures consider the guidance provided in RG 8.8 to ensure that occupational doses from the control and use of the sources are as low as is reasonably achievable (ALARA).

Various types and quantities of radioactive sources are employed to calibrate the process and effluent radiation monitors, the area radiation monitors, and portable and laboratory radiation detectors. Check sources that are integral to the area, process, and effluent monitors consist of small quantities of by-product material and do not require special handling, storage, or use procedures for radiation protection purposes. The same consideration applies to solid and liquid radionuclide sources of exempt quantities or concentrations which are used to calibrate or check the portable and laboratory radiation measurement instruments.

Instrument calibrators are normally used for calibrating gamma dose rate instrumentation. These may be self-contained, heavily shielded, multiple source calibrators. Beta and alpha radiation sources are also available for instrument calibration. Calibration sources are traceable to the National Institute of Standards and Technology, or equivalent.

Radiography sources are surveyed upon entry to the site. Radiation protection personnel maintain copies of the most recent leak test records for owner-controlled sources. Contractor radiography personnel provide copies of the most recent leak test records upon radiation protection personnel request. Radiography is conducted in accordance with approved procedures.

ENCLOSURE 5

Response to NRC RAI Letter 024

RAI Question 12.02-7

NRC RAI 12.02-7

Regulatory Guide 1.206 states that the applicant should describe any required radiation sources containing byproduct, source, and special nuclear material that may warrant shielding considerations, and, for any such sources, should provide a listing by isotope, quantity, form, and use for all of these sources that exceed 3.7 E+9 Bq (100 millicuries).

a) Describe the uses and shielding requirements of any radiation sources containing byproduct, source, and special nuclear material not described in the ESBWR DCD that may require shielding design considerations.

b) Provide a listing, by isotope, quantity, form, and use, of any of the sources described in your response to a) above that exceed 100 millicuries.

Dominion Response

Radiation Source Uses and Shielding Requirements

FSAR Section 12.2.1.5, "Other Contained Sources," in response to COL Information Item 12.2-4-A, identifies and describes check, calibration and radiography sources as additional radiation source uses not described in the DCD that may require shielding considerations. FSAR Appendix 12BB incorporates by reference NEI 07-03, Generic FSAR Template Guidance for Radiation Protection Program Description, which addresses in Section 12.5.4.2 the methods to maintain exposures ALARA, including shielding requirements for portable sources. Additional criteria for shielding are identified at the time of source purchase, when the specific isotope is known. NEI 07-03 Section 12.5.4 states that radiation protection procedures are established and implemented to provide adequate control over the receipt, possession, use, transfer and disposal of byproduct, source and special nuclear material and assure compliance with the requirements of 10 CFR Parts 19, 20, 50, 70 and 71.

Sources that Exceed 100 Millicuries

Dominion is aware of two standard calibration sources that exceed 100 millicuries. These standard calibration sources are a neutron (Am-Br) source and a Cs-137 source. Details of isotope type, quantity, form, shielding requirements, and use of future contained sources will be available when these required sources are purchased. These sources are controlled by the Radiation Protection Program described above.

Proposed COLA Revision

None.

ENCLOSURE 6

Response to NRC RAI Letter 024

RAI Question 12.02-8

NRC RAI 12.02-8

STD SUP 12.2-1 (Section 12.2.1.5) states that check sources that are integral to the area, process, and effluent monitors consist of small quantities of by-product material and do not require special handling, storage, or use procedures for radiation protection purposes. Specify your criteria for determining when radiation sources would not require special handling, storage, or use procedures for radiation protection purposes.

Dominion Response

Check sources used in area, process and effluent monitors do not require special handling, storage, or use procedures for radiation protection purposes when the source is actually physically located in (i.e., integral to) the monitors. These check sources are part of the radiation monitors and are not easily removed. Access to these sources would require procedures and tools to disassemble components of the monitors.

Proposed COLA Revision

None.

ENCLOSURE 7

Response to NRC RAI Letter 024

RAI Question 12.02-9

NRC RAI 12.02-9

Tier 2, Section 12.2.1.1.2, of the GEH ESBWR DCD states that during the first refueling outage, the Cf-252 reactor startup source and source holder will be removed from the reactor and moved to a designated location in the spent fuel pool (SFP). The DCD then states that operations and radiation protection personnel determine placement and duration of residence for the Cf-252 source and holder in the SFP. Identify in the North Anna FSAR where the issue of placement and duration of residence for the Cf-252 source and holder in the SFP is addressed.

Dominion Response

FSAR Section 12.2 incorporates by reference DCD Section 12.2, which states, "(t)he source and source holder is removed from the reactor during the first refueling outage and moved to a designated location in the spent fuel pool (SFP). Operations and radiation protection personnel determine placement and duration of residence for the Cf-252 source and holder in the SFP."

Details regarding the specific placement and duration of residence will be addressed as a part of the operational Radiation Protection Program described in FSAR Section 12.5.

The Cf-252 reactor startup sources are stored in the spent fuel pool in a designated location until final disposition can be determined.

Proposed COLA Revision

None.

ENCLOSURE 8

Response to NRC RAI Letter 024

RAI Question 12.03 – 12.04-1

NRC RAI 12.03 – 12.04-1

10 CFR 20.1501 requires the ability to identify potential radiological hazards. COL Information Item COL 12.3-2-A requires the COL applicant to discuss the placement of portable airborne radiation monitors as well as the operational considerations. COL Section 12.3.4 states that the placement of these monitors is located in COL Section 12.5. COL Section 12.5 references NEI template 07-03. NEI template 07-03 discusses types of radiation monitors that may be used at a plant as well as the corresponding operational considerations that will be considered for these monitors. However, this template does not discuss the criteria for placement of the airborne portable monitors.

a) Describe the criteria for placement and the sensitivities of portable airborne monitors that are used for normal operation, anticipated operational occurrences, and accident conditions.

b) Verify that North Anna, Unit 3, will have a sufficient number of portable airborne radiation monitors to sample air at all normally occupied locations where airborne radioactivity may exist.

Dominion Response

Criteria for Placement and Sensitivities of Portable Airborne Monitors
FSAR Appendix 12BB, "Radiation Protection," incorporates NEI 07-03, "Generic FSAR Template Guidance for Radiation Protection Program Description," by reference. NEI 07-03, Section 12.5.3.2 states that, "(c)ontinuous air monitors (CAMs) provide a means to observe trends in airborne radioactivity concentrations. CAMs equipped with local alarm capability are used in occupied areas where needed to alert personnel to sudden changes in airborne radioactivity concentrations."

NEI 07-03, Section 12.5.3.2, also states that radiation monitoring instrumentation and equipment will provide the appropriate detection capabilities, ranges, sensitivities and accuracies required for the types and levels of radiation anticipated at the plant and in the environs during routine operations, major outages, abnormal occurrences, and postulated accident conditions.

Number of Portable Airborne Radiation Monitors
Consistent with NEI 07-03, Section 12.5, Item III, adequate equipment is available to effectively implement the Radiation Protection Program. Milestone 1.c. of NEI 07-03, Section 12.5 ensures an adequate number of instruments is available to provide for appropriate detection capabilities to conduct radiation surveys in accordance with 10 CFR 20.1501 and 20.1502, including the capability to sample air at all normally occupied locations where airborne radioactivity may exist.

Proposed COLA Change

None.

ENCLOSURE 9

Response to NRC RAI Letter 024

RAI Question 12.03 – 12.04-2

NRC RAI 12.03 – 12.04-2

Per 10 CFR 20.1602, COL applicants must institute additional measures to ensure that an individual is not able to to gain unauthorized or or inadvertent access to Very High Radiation Areas Additionally, Section 12.5.4.4 of NEI 07-03 states that COL applicants should provide detailed drawings showing isometric views of each Very High Radiation Area and indicate physical access controls and radiation monitor locations for each area. Please describe the additional measures that will be used to prevent access for each Very High Radiaion area and provide detailed drawings showing the isometric views and indicate physical access controls and radiation monitors for each Very High Radiation area.

Dominion Response

GEH, in its April 5, 2008 response to DCD RAI 12.4-4 S02, provided detailed drawings showing isometric views of each Very High Radiation Areas (VHRA) and subsequently incorporated them into DCD Revision 5.

A description of the additional measures that are used to prevent access for each VHRA is provided in FSAR Section 12.5, "Operational Radiation Protection Program," and Appendix 12BB, "Radiation Protection," which incorporates by reference NEI template 07-03, "Generic FSAR Template Guidance for Radiation Program Protection Description."

Physical access controls for access into a VHRA are provided as part of the Radiation Protection Program. Entry into a VHRA is allowed only with a specific (Special) Radiation Worker Permit (RWP). Additional measures include provisions for postings, barricades and physical barriers for restricting access to VHRAs, including the use of locks that are keyed so only keys designated as VHRA can open the locks.

In accordance with NEI 07-03, Section 12.5.3.2, "(r)adiation monitoring instrumentation and equipment are selected, maintained and used to provide the appropriate detection capabilities, ranges, sensitivities and accuracies required for the types and levels of radiation anticipated at the plant and in the environs during routine operations, major outages, abnormal occurrences, and postulated accident conditions." Radiation monitors for each VHRA must meet this program requirement. The specific location of each radiation monitor is not yet known at this time, however, when detailed design engineering is complete, the drawings will be revised to show actual locations within the VHRA.

The above supplemental information will be added to FSAR Appendix 12BB to address the applicant site-specific information requested in NEI 07-03, Section 12.5.4.4.

Proposed COLA Change

FSAR Appendix 12BB will be revised as shown in the attached markup.

Markup of North Anna COLA

The attached markup represents Dominion's good faith effort to show how the COLA will be revised in a future COLA submittal in response to the subject RAI. However, the same COLA content may be impacted by revisions to the ESBWR DCD, responses to other COLA RAIs, other COLA changes, plant design changes, editorial or typographical corrections, etc. As a result, the final COLA content that appears in a future submittal may be somewhat different than as presented herein.

Appendix 12A Calculation of Airborne Radionuclides

This section of the referenced DCD is incorporated by reference with no departures or supplements.

Appendix 12B Calculation of Airborne Releases

This section of the referenced DCD is incorporated by reference with no departures or supplements.

STD SUP 12.1-1

Appendix 12AA ALARA Program

NEI 07-08, Generic FSAR Template Guidance for Ensuring that Occupational Radiation Exposures Are As Low As Is Reasonably Achievable (ALARA), which is currently under review by the NRC staff, is incorporated by reference. (Reference 12AA-201)

12AA.1 References

12AA-201 Nuclear Energy Institute (NEI), Generic FSAR Template Guidance for Ensuring that Occupational Radiation Exposures Are As Low As Is Reasonably Achievable (ALARA), NEI 07-08.

STD COL 12.1-1-A
STD COL 12.1-2-A
STD COL 12.1-3-A
STD COL 12.1-4-A
STD COL 12.5-1-A
STD COL 12.5-2-A
STD COL 12.5-3-A

Appendix 12BB Radiation Protection

NEI 07-03, Generic FSAR Template Guidance for Radiation Protection Program Description, which is currently under review by the NRC staff, is incorporated by reference with the following supplemental information. (Reference 12BB-201)

NEI 07-03 Section 12.5.2.4 Radiation Protection Technicians

Delete the third paragraph.

NEI 07-03 Section 12.5.3.1 Facilities

Delete the first and second paragraphs.

NEI 07-03 Section 12.5.3.2 Monitoring Instrumentation and Equipment

Delete the third paragraph.

NEI 07-03 Section 12.5.4.2 Methods to Maintain Exposures ALARA

Delete the second paragraph.

NEI 07-03 Section 12.5.4.4 Access Control

Isometric drawings of the Very High Radiation Areas (VHRA) are included in DCD Section 12.3.

Physical access controls include postings, barricades, physical barriers, and the use of locks that are keyed so only keys designated as VHRA can open the locks. Additionally, entry into a VHRA is allowed only with a specific (Special) radiation work permit.

12BB.1 References

12BB-201 Nuclear Energy Institute (NEI), Generic FSAR Template Guidance for Radiation Protection Program Description, NEI 07-03.

ENCLOSURE 10

Response to NRC RAI Letter 024

RAI Question 12.03 – 12.04-3

NRC RAI 12.03 – 12.04-3

STD CDI for North Anna FSAR Section 1.2.2.12.15, Zinc Injection System, states that a Zinc Injection System will not be utilized at North Anna, Unit 3. One of the benefits of utilizing a Zinc Injection System to inject depleted zinc (DZO) in the feedwater is to suppress cobalt plate-out on reactor building piping. Minimizing the plate-out of radioactive cobalt on reactor building piping can lead to potentially lower dose rates in the vicinity of this piping and result in correspondingly lower doses to personnel in this portion of the plant. Justify your decision to not utilize a Zinc Injection System at North Anna, Unit 3 in light of the requirement in 10 CFR 20.1101(b) which states that the licensee shall use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses that are as low as reasonably achievable (ALARA).

Dominion Response

The use of zinc injection has been beneficial in plants where cobalt-containing alloys have been employed. Radioactive cobalt plates out on surfaces, especially stainless steel, subsequently leading to increased dose rates and increased personnel exposure throughout the coolant system areas. Operating experience has indicated that a reduction in the use of cobalt can decrease dose rates. An example is Japan's ABWR Kashiwazaki-Kariwa 6 and 7 units where reduced dose rates have been achieved without zinc injection but with the use of low cobalt materials.

Based on this knowledge and operating experience, GEH reduced the amount of cobalt in contaminated applications throughout the plant and reduced the use of stainless steel in the coolant system. Cobalt is not a concern for the ESBWR stainless steel control rod drive mechanisms because the water that flows past these components is filtered prior to being injected into the vessel.

Additionally, ESBWR has no reactor coolant recirculation loops which are the primary contributors to drywell dose in existing BWRs.

Proposed COLA Change

None

ENCLOSURE 11

Response to NRC RAI Letter 024

RAI Question 12.03 – 12.04-4

NRC RAI 12.03 – 12.04-4

Since the North Anna FSAR for Chapter 12 is based on the format of the Tier 2 ESBWR DCD for Chapter 12, the FSAR contains Section 12.6 entitled "Minimization of Contamination and Radwaste Generation". However, in response to a staff RAI, GEH will be revising the DCD to incorporate the material contained in Section 12.6 of the DCD into Section 12.3 of the DCD. Therefore, the applicant should revise Chapter 12 of the North Anna FSAR to be consistent with the format of Chapter 12 of the ESBWR DCD.

Dominion Response

FSAR Chapter 12 will be revised to be consistent with the format of Chapter 12 of the ESBWR DCD once the revised DCD incorporating this change has been issued.

Proposed COLA Change

None.

ENCLOSURE 12

Response to NRC RAI Letter 024

RAI Question 12.05-1

NRC RAI 12.05-1

Per 10 CFR 50.34 (f)(2)(xxvii) (as supplemented by the criteria in Item III.D.3.3 of NUREG-0737) the Applicant shall provide equipment and associated training and procedures for accurately monitoring inplant radiation and airborne radioactivity (iodine concentration) in areas within the facility where plant personnel may be present during an accident and for a broad range of routine conditions. NEI template 07-03, which STD COL 12.5-2-A references, does not describe the numbers of the instruments that will be available to comply with this requirement, nor does it describe the training program and procedures on the use of these instruments.

a) Provide the number of instruments that the licensee will have available for use to determine the airborne iodine concentration in areas within the facility where plant personnel may be present during an accident.

b) Verify that the Applicant will have procedures and a training program to instruct plant personnel on how to accurately determine the airborne iodine concentration in areas within the facility where plant personnel may be present during an accident and for a broad range of routine conditions.

Dominion Response

FSAR Appendix 12BB, "Radiation Protection," incorporates NEI 07-03, "Generic FSAR Template Guidance for Radiation Protection Program Description," by reference.

Instruments for Use
Consistent with NEI 07-03, Section 12.5, Item III, adequate equipment is available to effectively implement the Radiation Protection Program. Milestone 1.c. of NEI 07-03, Section 12.5 ensures an adequate number of instruments are available to provide for appropriate detection capabilities to conduct radiation surveys in accordance with 10 CFR 20.1501 and 20.1502, including the capability to determine the airborne iodine concentration in areas within the facility where plant personnel may be present during an accident.

Procedures and Training
NEI 07-03 Section 12.5.2.4, paragraph 1, radiation protection technicians (RPTs) will carry out responsibilities defined in the Radiation Protection Program and procedures. Section 12.5.2.4, paragraph 2, states that RPTs will be trained and qualified under a program established in accordance with 10 CFR 50.120. These procedures and training ensure adequate determination of airborne iodine concentration in areas within the facility where plant personnel may be present during an accident and for a broad range of routine conditions.

Proposed COLA Change

None.

ENCLOSURE 13

Response to NRC RAI Letter 024

RAI Question 12.05-2

NRC RAI 12.05-2

NEI template 07-03 contains several sections that allow for site-specific alterations. Provide descriptions of any design or site-specific information for these areas. Areas which may have deviations include:

a) Alternative staff assigned to specific Radiation Protection Responsibilities

b) Alternative or additional Radiation Protection Facilities. Also, list facilities listed in the template that will be located off site and functions that will be carried out at another location or through a vendor.

c) Modified radiation protection monitoring instrumentation or equipment.

d) Use of special use respirator filters and disposable supplied air suits.

e) Alternate or additional procedures for maintaining exposures ALARA.

Dominion Response

No site-specific alterations from the generic program description of the Radiation Protection Program provided in NEI 07-03 have been identified. Therefore, the requested applicant site-specific information in NEI 07-03 is addressed by removing the bracketed sections from the template.

Proposed COLA Change

FSAR Appendix 12BB will be revised as shown on the attached markup.

Markup of North Anna COLA

The attached markup represents Dominion's good faith effort to show how the COLA will be revised in a future COLA submittal in response to the subject RAI. However, the same COLA content may be impacted by revisions to the ESBWR DCD, responses to other COLA RAIs, other COLA changes, plant design changes, editorial or typographical corrections, etc. As a result, the final COLA content that appears in a future submittal may be somewhat different than as presented herein.

Appendix 12A Calculation of Airborne Radionuclides

This section of the referenced DCD is incorporated by reference with no departures or supplements.

Appendix 12B Calculation of Airborne Releases

This section of the referenced DCD is incorporated by reference with no departures or supplements.

STD SUP 12.1-1

Appendix 12AA ALARA Program

NEI 07-08, Generic FSAR Template Guidance for Ensuring that Occupational Radiation Exposures Are As Low As Is Reasonably Achievable (ALARA), which is currently under review by the NRC staff, is incorporated by reference. (Reference 12AA-201)

12AA.1 References

12AA-201 Nuclear Energy Institute (NEI), Generic FSAR Template Guidance for Ensuring that Occupational Radiation Exposures Are As Low As Is Reasonably Achievable (ALARA), NEI 07-08.

STD COL 12.1-1-A
STD COL 12.1-2-A
STD COL 12.1-3-A
STD COL 12.1-4-A
STD COL 12.5-1-A
STD COL 12.5-2-A
STD COL 12.5-3-A

Appendix 12BB Radiation Protection

NEI 07-03, Generic FSAR Template Guidance for Radiation Protection Program Description, which is currently under review by the NRC staff, is incorporated by reference with the following supplemental information. (Reference 12BB-201)

NEI 07-03 Section 12.5.2.4 Radiation Protection Technicians

Delete the third paragraph.

NEI 07-03 Section 12.5.3.1 Facilities

Delete the first and second paragraphs.

NEI 07-03 Section 12.5.3.2 Monitoring Instrumentation and Equipment

Delete the third paragraph.

NEI 07-03 Section 12.5.3.3 Personal Protective Clothing and Equipment

Delete the last sentence in the first paragraph.

NEI 07-03 Section 12.5.4.2 Methods to Maintain Exposures ALARA

Delete the second paragraph.

NEI 07-03 Section 12.5.4.4 Access Control

Isometric drawings of the Very High Radiation Areas (VHRA) are included in DCD Section 12.3.

Physical access controls include postings, barricades, physical barriers, and the use of locks that are keyed so only keys designated as VHRA can open the locks. Additionally, entry into a VHRA is allowed only with a specific (Special) radiation work permit.

12BB.1 References

12BB-201 Nuclear Energy Institute (NEI), Generic FSAR Template Guidance for Radiation Protection Program Description, NEI 07-03.

ENCLOSURE 14

Response to NRC RAI Letter 024

RAI Question 12.05-3

NRC RAI 12.05-3

For each of the Radiation Protection Program Milestones listed below (and shown in Table 13.4-201 of the North Anna FSAR), provide a listing of the specific operational radiation protection program elements and procedures that will be implemented consistent with each milestone.

a) Prior to the initial receipt of by-product, source, or special nuclear materials (excluding Exempt Quantities as described in 10 CFR 30.18), and thereafter, when such radioactive materials are possessed under this license.

b) Prior to receiving reactor fuel under this license, and thereafter, when reactor fuel is possessed under this license.

c) Prior to initial loading of fuel in the reactor.

d) Prior to initial transfer, transport or disposal of radioactive materials. Verify that, prior to initial loading of fuel in the reactor, the radiation protection program described in NEI template 07-03 will be fully implemented, with the exception of the organization, facilities, equipment, instrumentation, and procedures necessary for transferring, transporting or disposing of radioactive materials in accordance with 10 CFR Part 20, Subpart K, and applicable requirements in 10 CFR Part 71. In addition, verify that the position of Radiation Protection Manager will be filled and at least one radiation protection technician for each operating shift, selected, trained and qualified consistent with the guidance in RG 1.8, will be onsite and on duty when fuel is initially loaded in the reactor, and thereafter, whenever fuel is in the reactor.

Dominion Response

NEI 07-03, "Generic FSAR Template Guidance for Radiation Program Protection Description," describes the specific operational radiation protection program elements including the stages in which the operational Radiation Protection Program are implemented. FSAR Appendix 12BB incorporates NEI 07-03 by reference.

Dominion will implement the Radiation Protection Program as described in NEI 07-03 in accordance with the milestones listed in FSAR Table 13.4-201.

Proposed COLA Change

None.

ENCLOSURE 15

Response to NRC RAI Letter 024

RAI Question 14.02-8

NRC RAI 14.02-8

In the case of radiation monitors and/or survey instruments with range selection, the "General Test Methods and Acceptance Criteria" in FSAR Section 14.2.9.1.3, please include a clarifying bullet to the effect, "proper functioning and operation of range selection and response in each range."

Dominion Response

This RAI makes reference to FSAR Section 14.2.9.1.3 and requests to include an additional clarifying statement. Dominion agrees with this assessment. However, as a result of Dominion's August 28, 2008 response to NRC Letter #17, RAI 14.02-5, this FSAR section has been deleted in its entirety.

As stated in the response to RAI 14.02-5, applicable standards for testing of radiation monitors and/or survey instruments are ANSI/IEEE N323A, "Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments," and ANSI/IEEE N323D, "Installed Radiation Protection." These standards address the aspects discussed in this RAI.

Proposed COLA Revision

None.

ENCLOSURE 16

Response to NRC RAI Letter 024

RAI Question Number 14.03.03-1

NRC RAI 14.03.03-1

For ITAAC Item 1 in Table 2.4.2.1, "ITAAC For Plant Service Water Reserve Storage Capacity," the design commitment is concerned with inventory of cooling water sufficient for RCCWS to cool from hour 0 through day 7, where as the acceptance criteria is concerned with usable water volume in cooling tower basins and pump forebay above pump minimum submergence water level and below minimum normal operating level, is a minimum of 2.6 million gallons. The design commitment and acceptance criteria are not in agreement or in parallel. SRP Section 14.3, Appendix A, Section IV.4.B, 'Column 3 –Acceptance Criteria' states that acceptance criteria should be objective and unambiguous. Please revise the design commitment and acceptance criteria so that the two are in agreement or in parallel. Also, the acceptance criteria should be objective and unambiguous, as required by SRP Section 14.3, Appendix A.

Dominion Response

The design commitment for the PSWS in COLA Part 10 Table 2.4.2-1 is that the system can remove 2.02×10^7 MJ (1.92×10^{10} BTU) over a period of seven days without active makeup, which is consistent with the interface requirement for the PSWS specified in DCD Tier 1, Section 4.1. Based on PSWS conformance with system design criteria as established in the DCD, this design commitment (interface requirement) is met by assuring that there is sufficient water available, without active makeup, to remove the specified amount of heat, which for North Anna Unit 3 equates to 2.6×10^6 gallons of usable water. Therefore, the design commitment and acceptance criterion are in agreement.

The acceptance criterion of 2.6×10^6 gallons of useable water is also an objective and unambiguously measurable parameter in that post-installation measurement (inspection) can readily confirm PSWS cooling tower basin sizing. Further, "useable water volume" is defined as the volume of water above the pump minimum submergence water level and below the minimum normal operating level, thereby assuring that there will be at least 2.6×10^6 gallons of water available for the subject PSWS cooling function.

Proposed COLA Revision

None.