Attachment 3 to

GNRO-2012/00039

Entergy Nuclear Grand Gulf Nuclear Station License Renewal Environmental Audit – Hydrology Patton, - Attachment B labeled "Enercon Study Assessing Groundwater Drawdown and Related Impacts"

Attachment B

Enercon Study Assessing Groundwater Drawdown and Related Impacts

ENERCON
Excellence—Every project. Every day.

May 19, 2010

Via Email

Mr. Rick Buckley, CHMM
Entergy Nuclear
Post Office Box 31995
Jackson, MS 31995-1995

RE: Radial Well Withdrawal Impacts Calculation ENTGGG071-CALC-001
Grand Gulf Nuclear Station, Unit 1

Dear Rick,

Per your request, please find attached the calculation package ENTGGG071-CALC-001 *Evaluation of Potential Impacts of Collector Well Groundwater Withdrawals, Grand Gulf Nuclear Station, Unit 1*. This analysis of the estimated drawdown resulting from operation of the Grand Gulf Nuclear Station (GGNS) radial collector wells was developed to support the Environmental Assessment (EA) of impacts resulting from Extended Power Uprate. The EA is anticipated to be used to support a request to the Nuclear Regulatory Commission for an Extended Power Uprate amendment of GGNS' Operating License. It was also anticipated that this calculation would be used to support the analysis of impacts of the radial collector well system in the Environmental Report for License Renewal for GGNS.

If you have any questions or require additional information, please feel free to call me at (918) 665-7693.

Thank you,

James A. Thomas
Manager, Electric Utility Environmental Services

Attachment – ENERCON Calculation ENTGGG071-CALC-001

ENERCON	CALCULATION COVER SHEET	CALC NO. ENTGGG071-CALC-001
		REV. 0
		PAGE NO. 1 of 25

TITLE	Evaluation of Potential Impacts of Radial (Ranney) Well Groundwater Withdrawals, Grand Gulf Nuclear Station, Unit 1	Client: Entergy Nuclear, Inc.
		Project: ENTGGG071

ITEM	COVER SHEET ITEMS	YES	NO
1	Does this calculation contain any open assumptions that require confirmation? (If **YES**, identify the assumptions)		X
2	Does this calculation serve as an "Alternate Calculation"? (If **YES**, identify the design verified calculation.) **Design Verified Calculation No.**__________		X
3	Does this calculation Supersede an existing Calculation? (If **YES**, identify the superseded calculation.) **Superseded Calculation No.**__________		X

Scope of Revision:

Initial issue.

Revision Impact on Results:

N/A

Study Calculation ☐ **Final Calculation** ☒

Safety Related ☐ **Non-Safety Related** ☒

(Print Name And Sign)

Originator: Randall N. Lantz, P.G. [signature]	**Date: 5/11/2010**
Reviewer: Haifeng Li / [signature] **Stacey Fredenberg /** [signature]	**Date: 5/13/2010**
Approver: James A. Thomas [signature]	**Date:** 5-14-2010

CALCULATION REVISION STATUS

REVISION	DATE	DESCRIPTION
0		Initial Issue

PAGE REVISION STATUS

PAGE NO.	REVISION	PAGE NO.	REVISION
1 – 25	0		

ATTACHMENT REVISION STATUS

ATTACHMENT NO.	PAGE NO.	REVISION NO.
1	1-2	0
2	1-5	0
3	1-3	0
4	1-2	0

ENERCON	CALCULATION DESIGN VERIFICATION PLAN AND SUMMARY SHEET	CALC. NO. ENTGGG071-CALC-001
		REV. 0
		PAGE NO. 3 of 25

Calculation Design Verification Plan:

Calculation inputs of hydrological characteristics for transmissivity, hydraulic conductivity, and line recharge; pumping rates; and distances to property boundaries shall be verified by checking the documented input with the source references, and if applicable further supported by more recent hydrogeological investigations, if any. Equations used are applicable based on references cited. Check the validity of the references for their intended use. All assumptions shall be evaluated and verified to determine if they are based on sound hydrological principles and practices. Calculation results shall be verified by random checks of at least three (3) equations for each radial well at each flow rate. Verify the methodology, results and conclusions.

(Print Name and Sign for Approval – mark "N/A" if not required)

Approver: James A. Thomas [signature]	Date: 5-14-2010

Calculation Design Verification Summary:

Design inputs, assumptions, methodology, results, and conclusions of Revision 0 are evaluated/verified and were found to be acceptable. All comments have been incorporated.

Based on the above summary, the calculation is determined to be acceptable.

(Print Name and Sign)

Design Verifier: Haifeng Li [signature]	Date: 05/13/2010
Others: Stacey Fredenberg [signature]	Date: 5/13/2010

ENERCON	CALCULATION REVIEW CHECKLIST	CALC. NO. ENTGGG071-CALC-001
		REV. 0
		PAGE NO. 4 of 25

Item	Cover Sheet Items	Yes	No	N/A
1	Design Inputs - Were the design inputs correctly selected, referenced latest revision, consistent with the design basis and incorporated in the calculation?	☒	☐	☐
2	Assumptions – Were the assumptions reasonable and adequately described, justified and/or verified, and documented?	☒	☐	☐
3	Quality Assurance – Were the appropriate QA classification and requirements assigned to the calculation?	☒	☐	☐
4	Codes, Standard and Regulatory Requirements – Were the applicable codes, standards, and regulatory requirements, including issue and addenda, properly identified and their requirements satisfied?	☐	☐	☒
5	Construction and Operating Experience – Has applicable construction and operating experience been considered?	☐	☐	☒
6	Interfaces – Have the design interface requirements been satisfied, including interactions with other calculations?	☐	☐	☒
7	Methods – Was the calculation methodology appropriate and properly applied to satisfy the calculation objective?	☒	☐	☐
8	Design Outputs – Was the conclusion of the calculation clearly stated, did it correspond directly with the objectives and are the results reasonable compared to the inputs?	☒	☐	☐
9	Radiation Exposure – Has the calculation properly considered radiation exposure to the public and plant personnel?	☐	☐	☒
10	Acceptance Criteria – Are the acceptance criteria incorporated in the calculation sufficient to allow verification that the design requirements have been satisfactorily accomplished?	☐	☐	☒
11	Computer Software – Is a computer program or software used, and if so, are the requirements of CSP 3.02 met?	☐	☐	☒

COMMENTS:

Print Name and Sign

Reviewer: Haifeng Li [signature]	**Date:** 05/13/2010
Others: Stacey Fredenberg [signature]	**Date:** 5/13/2010

TABLE OF CONTENTS

1.0 PURPOSE

The Plant Service Water system (PSW) for Grand Gulf Nuclear Station (GGNS) is supplied by radial (Ranney) collector wells installed along the bank of the Mississippi River. There are four (4) existing radial wells – PSW-1, PSW-3, PSW-4, and PSW-5. These radial wells are located in the floodplain that parallels the Mississippi River and are designed to derive water from the Mississippi River via induced infiltration. The wells withdraw groundwater from Mississippi River alluvial deposits east of the river.

Additional cooling tower make-up water is anticipated to be needed (~3,200 gpm) due to the increase in heat load generated as a result of Extended Power Uprate (EPU), along with the associated increase in water loss through evaporation, blowdown and drift. A new radial well is being installed to ensure that plant service water availability is maintained during EPU conditions since GGNS' existing radial wells degrade over time and thus cannot perform at their design capacity. Radial well PSW-6 is scheduled to be installed north of the barge slip and operational in March 2012. Figure 1 shows the approximate locations of the existing radial wells and PSW-6.

The purpose of the following analysis was to provide an evaluation of the radius of influence effects on the Mississippi River Alluvial Aquifer due to pumping from all five radial wells - PSW-1, PSW-3, PSW-4 and PSW-5, including anticipated pumping from PSW-6, scheduled for installation in 2012. This includes the following:

- Determination of the aquifer drawdown effects due to pumping of the five (5) radial wells at rates sufficient to supply PSW needs at EPU conditions; assuming all five (5) radial wells are pumping at maximum Mississippi Department of Environmental Quality (MDEQ) permitted capacity.
- Water withdrawal impacts related to operation of the PSW system on potential offsite groundwater users.

This calculation is based on historic information and site conditions related to aquifer characteristics developed for GGNS by other vendors. For example, aquifer geology data mentioned in this calculation is based on data supplied by studies completed during the licensing of GGNS Unit 1, and supplemented by recent site characterization studies developed for the Combined Operating License (COL) Application developed for Unit 3. This data is accepted without additional verification. Aquifer characteristics parameters such as hydraulic conductivity (K), Transmissivity (T), aquifer thickness (m), line recharge, and other are taken from previous GGNS calculations which were completed by other vendors. The aquifer parameter values are representative of tests performed at specific point locations representative of conditions at the time of the tests. These values are accepted without additional verification. The verification of these parameters is limited to confirmation that the values used are accurately drawn from the referenced documents. Utilization of these aquifer characteristics in this calculation is based on best professional judgment as being appropriate for the current calculation. Assumptions cited in Section 4.0 and reflected as input values in the calculations in Section 6.0 contain no open assumptions that require future confirmation.

2.0 SUMMARY OF RESULTS AND CONCLUSIONS

Drawdown at any specific point of a well field will be the cumulative drawdown at that location from each well pumping within the area. The individual drawdowns from each PSW well at the five (5) property line observation points (P1 and P3 through P6) are summarized and totaled in Table 3 (nominal pumping rate Q_{ave}) and Table 4 (maximum pumping rate Q_{max}) to give an estimated cumulative drawdown amount at the specified observation point:

Table 1
Groundwater Drawdown at the Property Line Observation Points (ft.) at Nominal Pumping Rates Q_{ave}

PSW Well	P1	P3	P4	P5	P6
PSW-1	3.75	2.52	1.68	0.11	0.09
PSW-3	0.74	0.81	0.78	0.17	0.13
PSW-4	0.40	0.44	0.45	0.31	0.25
PSW-5	0.26	0.28	0.29	0.39	0.32
PSW-6	0.17	0.18	0.19	0.74	0.90
Total	5.32	4.23	3.39	1.72	1.69

Table 2
Groundwater Drawdown at the Property Line Observation Points (ft.) at Maximum Pumping Rates Q_{max} = 10,000 gpm

PSW Well	P1	P3	P4	P5	P6
PSW-1	8.71	5.85	3.92	0.26	0.22
PSW-3	1.80	1.97	1.91	0.40	0.32
PSW-4	0.76	0.82	0.86	0.58	0.48
PSW-5	0.50	0.53	0.55	0.75	0.62
PSW-6	0.32	0.34	0.36	1.40	1.69
Total	12.09	9.51	7.60	3.39	3.33

The greatest groundwater drawdown is estimated to be at the southern property boundary, approximately 12.09 feet with all five (5) wells pumping at the 10,000 gpm, in the vicinity of observation point P1. Assuming an average aquifer thickness of 81.20 feet (Table 2, PSW-1), this results in a net reduction of the available aquifer thickness on the southern property line at P1 of 14.89% [(12.09 ft./81.20 ft.) * 100=14.89%]. If an assumed aquifer thickness of 81.26 ft. exists similar to PSW-5 at Observation Point P5 (See Figure 3) on the GGNS northern property boundary, the reduction of available capacity is 3.39 feet, or 4% [(3.39 ft./81.26 ft.) * 100 = 4.17%)].

Due to the recharge provided by the Mississippi River, groundwater withdrawals from the GGNS PSW well field would not be expected to have an impact on offsite groundwater users west of the river.

3.0 REFERENCES

Bechtel 1986. Bechtel, *Radial Wells 1, 3, 5 - Reduction of Multiple Well Test Data (Geotech Calc G-035)*. Approved 7/31/86.

Driscoll 1986. Groundwater and Wells, Fletcher G. Driscoll, Editor, Johnson Filtration Systems, Inc. 1986.

GGNS (Grand Gulf Nuclear Station) 2008. Grand Gulf Nuclear Station Unit 3 Combined License Application, Part 2: Final Safety Analysis Report, Revision 0. February 2008.

GGNS (Grand Gulf Nuclear Station) 2009. Updated Safety Analysis Report. 2009.

GWA 1994, Ground Water Associates, Evaluation of Means for Supplying Plant Service Water Requirements, Grand Gulf Nuclear Station, June 1994.

Hydro 1989. Hydro Group, Inc., Annual Report, Collector Well Performance, PSW Wells 1, 3 ,4, and 5, Grand Gulf Nuclear Station, February 1989.

MDEQ 2010. Mississippi Department of Environmental Quality, Permit to Divert or Withdraw for Beneficial Use the Public Waters, Permit Number MS-GW-16714, System Energy Resources, Inc., March 2010.

Ranney 1975. Ranney Company, Report to Mississippi Power And Light Company, Jackson, MS, Hydrogeological Investigation for Ranney Collector Wells at Grand Gulf Nuclear Station, Grand Gulf, MS. 1975.

Ranney 1983. Ranney Company, Multiple Collector Test and Lateral Evaluation Program, Ranney Wells 1,3 & 5, for Mississippi Power and Light, Grand Gulf Nuclear Station, December 1983.

4.0 ASSUMPTIONS/DESIGN INPUTS

4.1 RADIAL WELL FLOW ESTIMATES

Based on input from Entergy, additional cooling tower make-up water is anticipated to be needed (~3,200 gpm) due to the increase in heat load generated as a result of Extended Power Uprate (EPU), along with the associated increase in water loss through evaporation, blowdown and drift.

A maximum flow rate of 10,000 gpm was established from the MDEQ permitted well capacities for all five (5) radial wells [MDEQ 2010]. The use of the maximum permitted flow rates is not intended to indicate that actual well yields of 10,000 gpm could be sustained. The use of Q_{max} = 10,000 gpm is considered to provide additional conservatism in the estimate of drawdown effects at the GGNS property boundaries.

Therefore, 10,000 gpm is established as the assumed maximum flow rate from each radial well for this calculation.

4.2 AQUIFER PROPERTIES

Historic pump testing data was reviewed for the existing PSW wells. This historic pump test data was used to estimate relevant aquifer properties [Ranney 1975, Ranney 1983]. Aquifer properties (transmissivity, hydraulic conductivity, line recharge, thickness) and observed drawdowns during pump tests are used below as input for the determination of groundwater drawdown at the closest property boundary. Based on information from Entergy, there have been no new pump tests performed in the area radial wells of the GGNS site since 1983. However, the aquifer properties reported from those pump tests remain valid estimates of aquifer conditions since the subsurface geology has not changed since that time, and hydraulic conditions of the site have not been altered. That is, the hydraulic settings (river location, river flows, and areas of recharge) have not changed.

Groundwater drawdown due to pumping in the unconfined Mississippi River Alluvial Aquifer at the location of the PSW radial wells (PSW-1, PSW-3, PSW-4, PSW-5, and the proposed PSW-6) adjacent to the Mississippi River is dependent on two hydrologic regimes within the aquifer surrounding the PSW wells. The groundwater aquifer on the western side of the well field is dominated by recharge from the Mississippi River. Although heavily influenced by the Mississippi River, the aquifer on the eastern side of the river also receives recharge from local precipitation, local flooding events, and discharge at the bluffs/floodplain interface from the Pleistocene age undifferentiated terrace deposits (locally identified as the Upland Complex) (Figure 2). These are described in the original Unit 1 licensing documents, as well as more recent evaluations [Ranney 1975, Ranney 1983, GGNS 2008, GGNS 2009].

The calculations below use radial well information developed from collector wells PSW-1, PSW-3, and PSW-5 pumping tests at conditions observed on October 9, 1983 at 12:30 hours [Bechtel 1986]. Mississippi River level was reported at 41.52 ft. msl and is assumed to be consistent throughout the duration of the pumping test for all three wells [Bechtel 1986].

Table 3 provides inputs for the calculations below based on the reference cited:

Table 3
Aquifer and PSW Well Parameters (Bechtel 1986)

Parameter		PSW-1	PSW-3	PSW-5
Q	Total Flow rate (gpm)	4300	4100	5200
K	Hydraulic Conductivity (gpd/ft.^{2})	2085	2350	2500
m	Average Aquifer Thickness (ft.)	81.20	75.41	81.26
T	Transmissivity (gpd/ft.)	169,302	177,214	203,150
a	Distance to line recharge (ft.)	850	850	850

The flow rates from PSW-1, PSW-3, and PSW-5 are used in the calculations to reflect flow rates for comparison against the maximum assumed flow rates of 10,000 gpm per well.

Hydraulic conductivity (K) for PSW-4 is listed as 1850 gpd/ft.^{2} with a nominal pumping rate of 5300 gpm, based on operations in 1988 [Hydro 1989]. As PSW-4 lies approximately midway between PSW-3 and PSW-5, Transmissivity (T) used for drawdown calculation is the average of the PSW-3 and PSW-5 (See values in Table 3), or (190,182 gpd/ft.).

PSW-6 has not yet been installed at GGNS. Hydraulic conductivity (K) for PSW-6 is assumed to be the average of the PSW-1, PSW-3 and PSW-5 values (in Table 2) and calculated as 2312 gpd/ft.^{2}. A nominal pumping rate of 5300 gpm is also assumed to be consistent with the PSW-4 estimation. Transmissivity (T) used for drawdown calculation is the average of the PSW-1, PSW-3 and PSW-5 values in Table 3 (183,222 gpd/ft.).

4.3 MISSISSIPPI RIVER RECHARGE EFFECTS

Plant service water is supplied from radial collector wells located in the floodplain that parallels the Mississippi River (Figure 4). The collector wells are designed to derive water from the Mississippi River via induced infiltration.

Multiple assessments and yield calculations have been performed for radial wells installed at GGNS. The distance to the "line source of recharge" has been assumed to be approximately 850 ft. to the west of the wells [Bechtel 1986]. The "line source of recharge" is a theoretical line where the infiltration rate from the recharge source (Mississippi River) is balanced with the groundwater withdrawal rate; therefore producing a line of zero drawdown in the underlying aquifer. The line recharge distance is measured from the pumping well. The Bechtel 1986 calculations derive line recharge distances specific to PSW-1, PSW-3, and PSW-5 at the cited flows (Q) and river stage. Bechtel did not calculate a line recharge distance for PSW-4 or PSW-6. ENERCON uses an assumed line recharge distance of 850 feet in this current calculation package, as a reasonable distance. Use of this line recharge distance is consistent with other calculations performed by Bechtel [Bechtel 1986]. The Mississippi River is approximately 3300 feet wide at the location of GGNS. Pumping from the GGNS PSW wells on the eastern side of the Mississippi will not affect groundwater users on the western side of the Mississippi River.

Previous aquifer testing at the locations of PSW-1, PSW-3, and PSW-5 (Figure 5) showed a sharp groundwater gradient from the Mississippi River bank to the pumping well, and a more gradual, but limited, cone of depression on the landward side of the well [Ranney 1983].

4.4 MISSISSIPPI RIVER ALLUVIAL AQUIFER EFFECTS

East of the Mississippi River, the radial wells will draw groundwater not only from induced infiltration from the Mississippi River, but also from the alluvial aquifer itself. Groundwater pumping tests were conducted between 1975 and 1983 for aquifer parameter and yield determinations; however, none of the tests were conducted at pumping rates of 10,000 gpm [Bechtel 1986].

4.5 DRAWDOWN OBSERVATION POINT DISTANCES

Distances from each radial well (PSW-1, PSW-3, PSW-4, PSW-5, and PSW-6) were developed by ENERCON to a point approximately corresponding to the nearest property boundary. These distances were developed approximations using measurement capabilities of publically available aerial photography software (Google Earth). These distances are not surveyed distances, and therefore any drawdowns derived from the calculations below are representative of the estimated effects at the specified distance from the cited well. Figure 3 provides locations of observation points on the GGNS property boundary and well locations. Using Equation 2, the distances in Table 4 were used to calculate the drawdown at the GGNS property boundary for a location nearest to each of the collector wells. Observation points P1, P3, and P4 are located on the southern property boundary. Observation points P5 and P6 are located on the northern property boundary (Figure 3).

Table 4
Distance (r) between PSW Wells and Nearest Property Boundaries (ft.)

	Observation Point				
PSW Well	**P1**	**P3**	**P4**	**P5**	**P6**
PSW-1	1050	1450	1920	8650	9450
PSW-3	3000	2850	2900	6700	7550
PSW-4	4650	4450	4350	5350	5900
PSW-5	5600	5400	5300	4500	5000
PSW-6	7400	7150	7000	3400	3050

4.6 RIVER STAGE

The calculations below use radial well information developed from collector wells PSW-1, PSW-3, and PSW-5 pumping tests at conditions observed on October 9, 1983 at 12:30 hours [Bechtel 1986]. Mississippi River level was reported at 41.52 ft. msl and is assumed to be constant. Actually, the river level at 41.52 ft. msl is a relatively low stage of the river, and adds additional conservatism to the consideration groundwater drawdown. Maximum well drawdown in each PSW is fixed, based on the established pump intake elevation. The GGNS minimum water levels for each well are established above the actual pump intake. The river level affects the available saturated thickness of the aquifer, and in effect the available well yield is reduced when the river level

declines because of a corresponding reduction of the aquifer saturated thickness. The relationship between aquifer thickness and available yield is illustrated by Darcy's equilibrium well equation:

$Q = (K(H^2-h^2))/(1055 \log R/r)$ (Driscoll 1986, pg. 213)

Where:

Q = well yield or pumping rate (gpm)
K = Hydraulic conductivity of the formation (gpd/ft.^{2})
H = static head measured from the bottom of the aquifer (ft.)
h = depth of water in the well while pumping (ft.)
R = radius of the cone of depression (ft.)
r = radius of the well (ft.)

As shown in Darcy's equation, if the radius (R) of the cone of depression is assumed to remain constant, the flow (Q) is reduced as the static head (H) decreases. If the flow is held constant, the radius of the cone of depression is decreased, if the static head decreases. The aquifer parameters (transmissivity, hydraulic conductivity) cited in Table 3 are based on the point in time where the river level was 41.52 ft. above mean sea level. All calculations below are based on assumption of a constant river stage and aquifer potentiometric surface elevation of 41.52 ft. above mean sea level.

5.0 METHODOLOGY

ENERCON reviewed readily available hydrogeological reference literature for methodologies to best estimate drawdown effects that would include the maximum number of site conditions, such as recharge from the Mississippi River, other local recharges, horizontal collector well design and operating conditions, and multiple well interferences. Most hydrogeologic references discuss recharge conditions such as rivers, lakes, and local precipitation, but cite the need to use pump test data to predict drawdown at distance. This is because site specific aquifer properties control observable drawdown. Ultimately, ENERCON chose to use the equations previously used for estimating radial well yield as most applicable, because the equations consider the recharge from the river. Use of the same equations also provides for consistency of evaluation methodologies. Equation 1 (Section 5.1) includes recharge from the river, as a line recharge boundary, although it does not include other recharge sources (e.g., precipitation events). Therefore, it must be noted that the calculations performed below are conservative, and will overestimate the probable drawdown.

5.1 EQUATIONS AND INPUT PARAMETERS

The method used for this calculation is based on the equations utilized by Bechtel in 1983 to determine drawdown interference effects between adjacent PSW well pumping [Bechtel 1986]. Use of these equations is consistent with previous evaluations at the site; and the equations take the recharge of the Mississippi River into account in the evaluation. The equation for drawdown is derived from the following equation (Equation 1) for calculation of aquifer transmissivity:

$$T = \frac{527.7Q\log\left(\frac{\sqrt{4a^2+r^2}}{r}\right)}{s}$$ (Equation 1) [Bechtel 1986, sheet 2 of 35, Attachment 2]

Where:

- T = Transmissivity (gpd/ft.)
- Q = Pumping rate, gpm
- a = Distance from pumping well to the line source of recharge* (ft.)
- r = Distance from pumping well to a selected observation point (ft.)
- s = Groundwater drawdown at the selected observation point r (ft.)

* The "line source of recharge" is a theoretical line where the infiltration rate from the recharge source (Mississippi River) is balanced with the groundwater withdrawal rate; therefore producing a line of zero drawdown in the underlying aquifer.

Rearranging Equation 1 to solve for the groundwater drawdown (s) at an observation point (r) yields the following:

$$s = \frac{527.7Q\log\left(\frac{\sqrt{4a^2+r^2}}{r}\right)}{T}$$ (Equation 2)

6.0 CALCULATIONS

The following is an assessment of the drawdown, both individually and cumulatively, at each of the five observation points specified in Table 1. The assessment will evaluate the observation point drawdown for a nominal flow rate (Q_{ave}), used in the Bechtel assessment [Bechtel 1986]. A maximum flow rate of 10,000 gpm was established from the MDEQ permitted well capacities for all five (5) radial wells, as requested by Entergy. The use of the maximum permitted flow rates is not intended to indicate that actual well yields of 10,000 gpm could be sustained. The use of Q_{max} = 10,000 gpm is considered to provide additional conservatism in the estimate of drawdown effects at the GGNS property boundaries.

The calculations below use radial well information developed from collector wells PSW-1, PSW-3, and PSW-5 pumping tests at conditions observed on October 9, 1983 at 12:30 hours [Bechtel 1986]. Mississippi River level was reported at 41.52 ft. msl and is assumed to be consistent. Actually, the river level at 41.52 ft. msl is a relatively low

stage of the river, and adds additional conservatism to the consideration groundwater drawdown.

6.1 ESTIMATED DRAWDOWN AT GGNS PROPERTY BOUNDARIES

6.1.1 PSW-1 Estimated Drawdown

Using Equation 2, and parameter values from Tables 1 and 2, the drawdown at each observation point for a nominal flow rate (Q_{ave}) of 4,300 gpm, and for a maximum flow rate (Q_{max}) of 10,000 gpm is as follows:

Q_{ave} = 4300 gpm	Q_{max} = 10,000 gpm
PSW-1: Observation Point P1	
$s = \frac{527.7*4300*\log(\frac{(4*850^2+1050^2)^{0.5}}{1050})}{169302}$	$s = \frac{527.7*10000*\log(\frac{(4*850^2+1050^2)^{0.5}}{1050})}{169302}$
s = 3.75 ft.	s = 8.71 ft.
PSW-1: Observation Point P3	
$s = \frac{527.7*4300*\log(\frac{(4*850^2+1450^2)^{0.5}}{1450})}{169302}$	$s = \frac{527.7*10000*\log(\frac{(4*850^2+1450^2)^{0.5}}{1450})}{169302}$
s = 2.52 ft.	s = 5.85 ft.
PSW-1: Observation Point P4	
$s = \frac{527.7*4300*\log(\frac{(4*850^2+1920^2)^{0.5}}{1920})}{169302}$	$s = \frac{527.7*10000*\log(\frac{(4*850^2+1920^2)^{0.5}}{1920})}{169302}$
s = 1.68 ft.	s = 3.92 ft.
PSW-1: Observation Point P5	
$s = \frac{527.7*4300*\log(\frac{(4*850^2+8650^2)^{0.5}}{8650})}{169302}$	$s = \frac{527.7*10000*\log(\frac{(4*850^2+8650^2)^{0.5}}{8650})}{169302}$
s = 0.11 ft.	s = 0.26 ft.
PSW-1: Observation Point P6	
$s = \frac{527.7*4300*\log(\frac{(4*850^2+9450^2)^{0.5}}{9450})}{169302}$	$s = \frac{527.7*10000*\log(\frac{(4*850^2+9450^2)^{0.5}}{9450})}{169302}$
s = 0.09 ft.	s = 0.22 ft.

The nearest property boundary to PSW-1 is near Observation Point P1 in Table 2 (southern property boundary) and is calculated to have a drawdown of 3.75 ft. at 4,300 gpm, and 8.71 ft. at 10,000 gpm. PSW-1 is approximately 8,650 ft. from the nearest point on the northern property boundary (Observation Point P5), and is calculated to cause approximately 0.11 ft. of drawdown at a pumping rate of 4,300 gpm, and approximately 0.26 ft. of drawdown at a pumping rate of 10,000 gpm.

6.1.2 PSW-3 Estimated Drawdown

Using Equation 2, and parameter values from Tables 1 and 2, the drawdown at each observation point for a nominal flow rate (Q_{ave}) of 4,100 gpm, and for a maximum flow rate (Q_{max}) of 10,000 gpm is as follows:

Q_{ave} = 4100 gpm	Q_{max} = 10,000 gpm
PSW-3: Observation Point P1	
$s = \frac{527.7*4100*\log(\frac{(4*850^2+3000^2)^{0.5}}{3000})}{177214}$	$s = \frac{527.7*10000*\log(\frac{(4*850^2+3000^2)^{0.5}}{3000})}{177214}$
s = 0.74 ft.	s = 1.80 ft.
PSW-3: Observation Point P3	
$s = \frac{527.7*4100*\log(\frac{(4*850^2+2850^2)^{0.5}}{2850})}{177214}$	$s = \frac{527.7*10000*\log(\frac{(4*850^2+2850^2)^{0.5}}{2850})}{177214}$
s = 0.81 ft.	s = 1.97 ft.
PSW-3: Observation Point P4	
$s = \frac{527.7*4100*\log(\frac{(4*850^2+2900^2)^{0.5}}{2900})}{177214}$	$s = \frac{527.7*10000*\log(\frac{(4*850^2+2900^2)^{0.5}}{2900})}{177214}$
s = 0.78 ft.	s = 1.91 ft.
PSW-3: Observation Point P5	
$s = \frac{527.7*4100*\log(\frac{(4*850^2+6700^2)^{0.5}}{6700})}{177214}$	$s = \frac{527.7*10000*\log(\frac{(4*850^2+6700^2)^{0.5}}{6700})}{177214}$
s = 0.17 ft.	s = 0.40 ft.
PSW-3: Observation Point P6	
$s = \frac{527.7*4100*\log(\frac{(4*850^2+7550^2)^{0.5}}{7550})}{177214}$	$s = \frac{527.7*10000*\log(\frac{(4*850^2+7550^2)^{0.5}}{7550})}{177214}$
s = 0.13 ft.	s = 0.32 ft.

The nearest property boundary to PSW-3 is near Observation Point P3 in Table 2 (southern property boundary) and is calculated to have a drawdown of 0.81 ft. at 4,100 gpm, and 1.97 ft. at 10,000 gpm. PSW-3 is approximately 6,700 ft. from the nearest point on the northern property boundary (Observation Point P5), and is calculated to cause approximately 0.17 ft. of drawdown at a pumping rate of 4,100 gpm, and approximately 0.40 ft. of drawdown at a pumping rate of 10,000 gpm.

6.1.3 PSW-4 Estimated Drawdown

Hydraulic conductivity (K) for PSW-4 is listed as 1850 gpd/ft.[2] with a nominal pumping rate of 5300 gpm, based on operations in 1988 [Ranney 1983, Hydro 1989]. As PSW-4 lies approximately midway between PSW-3 and PSW-5, Transmissivity (T) used for drawdown calculation is the average of the PSW-3 and PSW-5 (See values in Table 2), or (190,182 gpd/ft.).

Q_{ave} = 5300 gpm **Q_{max} = 10,000 gpm**

PSW-4: Observation Point P1

$s = \frac{527.7*5300*\log(\frac{(4*850^2+4650^2)^{0.5}}{4650})}{190182}$	$s = \frac{527.7*10000*\log(\frac{(4*850^2+4650^2)^{0.5}}{4650})}{190182}$
s = 0.40 ft.	s = 0.76 ft.

PSW-4: Observation Point P3

$s = \frac{527.7*5300*\log(\frac{(4*850^2+4450^2)^{0.5}}{4450})}{190182}$	$s = \frac{527.7*10000*\log(\frac{(4*850^2+4450^2)^{0.5}}{4450})}{190182}$
s = 0.44 ft.	s = 0.82 ft.

PSW-4: Observation Point P4

$s = \frac{527.7*5300*\log(\frac{(4*850^2+4350^2)^{0.5}}{4350})}{190182}$	$s = \frac{527.7*10000*\log(\frac{(4*850^2+4350^2)^{0.5}}{4350})}{190182}$
s = 0.45 ft.	s = 0.86 ft.

PSW-4: Observation Point P5

$s = \frac{527.7*5300*\log(\frac{(4*850^2+5350^2)^{0.5}}{5350})}{190182}$	$s = \frac{527.7*10000*\log(\frac{(4*850^2+5350^2)^{0.5}}{5350})}{190182}$
s = 0.31 ft.	s = 0.58 ft.

PSW-4: Observation Point P6

$s = \frac{527.7*5300*\log(\frac{(4*850^2+5900^2)^{0.5}}{5900})}{190182}$	$s = \frac{527.7*10000*\log(\frac{(4*850^2+5900^2)^{0.5}}{5900})}{190182}$
s = 0.25 ft.	s = 0.48 ft.

The nearest property boundary to PSW-4 is near Observation Point P4 in Table 2 (southern property boundary) and is calculated to have a drawdown of 0.45 ft. at 5,300 gpm, and 0.86 ft. at 10,000 gpm. PSW-4 is approximately 5,350 ft. from the nearest point on the northern property boundary (Observation Point P5), and is calculated to cause approximately 0.31 ft. of drawdown at a pumping rate of 5,300 gpm, and approximately 0.58 ft. of drawdown at a pumping rate of 10,000 gpm.

6.1.4 PSW-5 Estimated Drawdown

Using Equation 2, and parameter values from Tables 1 and 2, the drawdown at each observation point for a nominal flow rate (Q_{ave}) and for a maximum flow rate (Q_{max}) of 10,000 gpm is as follows:

Q_{ave} = 5200 gpm	Q_{max} = 10,000 gpm
PSW-5: Observation Point P1	
$s = \frac{527.7*5200*\log(\frac{(4*850^2+5600^2)^{0.5}}{5600})}{203150}$	$s = \frac{527.7*10000*\log(\frac{(4*850^2+5600^2)^{0.5}}{5600})}{203150}$
s = 0.26 ft.	s = 0.50 ft.
PSW-5: Observation Point P3	
$s = \frac{527.7*5200*\log(\frac{(4*850^2+5400^2)^{0.5}}{5400})}{203150}$	$s = \frac{527.7*10000*\log(\frac{(4*850^2+5400^2)^{0.5}}{5400})}{203150}$
s = 0.28 ft.	s = 0.53 ft.
PSW-5: Observation Point P4	
$s = \frac{527.7*5200*\log(\frac{(4*850^2+5300^2)^{0.5}}{5300})}{203150}$	$s = \frac{527.7*10000*\log(\frac{(4*850^2+5300^2)^{0.5}}{5300})}{203150}$
s = 0.29 ft.	s = 0.55 ft.
PSW-5: Observation Point P5	
$s = \frac{527.7*5200*\log(\frac{(4*850^2+4500^2)^{0.5}}{4500})}{203150}$	$s = \frac{527.7*10000*\log(\frac{(4*850^2+4500^2)^{0.5}}{4500})}{203150}$
s = 0.39 ft.	s = 0.75 ft.
PSW-5: Observation Point P6	
$s = \frac{527.7*5200*\log(\frac{(4*850^2+5000^2)^{0.5}}{5000})}{203150}$	$s = \frac{527.7*10000*\log(\frac{(4*850^2+5000^2)^{0.5}}{5000})}{203150}$
s = 0.32 ft.	s = 0.62 ft.

The nearest property boundary to PSW-5 is near Observation Point P5 in Table 2 (northern property boundary) and is calculated to have a drawdown of 0.39 ft. at 5,200 gpm, and 0.75 ft. at 10,000 gpm. PSW-5 is approximately 5,300 ft. from the nearest point on the southern property boundary (Observation Point P4), and is calculated to cause approximately 0.29 ft. of drawdown at a pumping rate of 5,200 gpm, and approximately 0.55 ft. of drawdown at a pumping rate of 10,000 gpm.

6.1.5 PSW-6 Estimated Drawdown

PSW-6 has not yet been installed at GGNS. Hydraulic conductivity (K) for PSW-6 is assumed to be the calculated average of the PSW-1, PSW-3 and PSW-5 values (in Table 2) and calculated as 2312 gpd/ft.^{2}. A nominal pumping rate of 5300 gpm is also assumed to be consistent with the PSW-4 estimation. Transmissivity (T) used for drawdown calculation is the average of the PSW-1, PSW-3 and PSW-5 values in Table 2 (183,222 gpd/ft.).

Q_{avc} = 5300 gpm | **Q_{max} = 10,000 gpm**

PSW-6: Observation Point P1

$$s = \frac{527.7*5300*\log(\frac{(4*850^2+7400^2)^{0.5}}{7400})}{183222}$$

s = 0.17 ft.

$$s = \frac{527.7*10000*\log(\frac{(4*850^2+7400^2)^{0.5}}{7400})}{183222}$$

s = 0.32 ft.

PSW-6: Observation Point P3

$$s = \frac{527.7*5300*\log(\frac{(4*850^2+7150^2)^{0.5}}{7150})}{183222}$$

s = 0.18 ft.

$$s = \frac{527.7*10000*\log(\frac{(4*850^2+7150^2)^{0.5}}{7150})}{183222}$$

s = 0.34 ft.

PSW-6: Observation Point P4

$$s = \frac{527.7*5300*\log(\frac{(4*850^2+7000^2)^{0.5}}{7000})}{183222}$$

s = 0.19 ft.

$$s = \frac{527.7*10000*\log(\frac{(4*850^2+7000^2)^{0.5}}{7000})}{183222}$$

s = 0.36 ft.

PSW-6: Observation Point P5

$$s = \frac{527.7*5300*\log(\frac{(4*850^2+3400^2)^{0.5}}{3400})}{183222}$$

s = 0.74 ft.

$$s = \frac{527.7*10000*\log(\frac{(4*850^2+3400^2)^{0.5}}{3400})}{183222}$$

s = 1.40 ft.

PSW-6: Observation Point P6

$$s = \frac{527.7*5300*\log(\frac{(4*850^2+3050^2)^{0.5}}{3050})}{183222}$$

s = 0.90 ft.

$$s = \frac{527.7*10000*\log(\frac{(4*850^2+3050^2)^{0.5}}{3050})}{183222}$$

s = 1.69 ft.

The nearest property boundary to PSW-6 is near Observation Point P6 in Table 2 (northern property boundary) and is calculated to have a drawdown of 0.90 ft. at 5,300 gpm, and 1.69 ft. at 10,000 gpm. PSW-6 is approximately 7,000 ft. from the nearest point on the southern property boundary (Observation Point P4), and is calculated to cause approximately 0.19 ft. of drawdown at a pumping rate of 5,300 gpm, and approximately 0.36 ft. of drawdown at a pumping rate of 10,000 gpm.

6.1.6 Cumulative Estimated Drawdown

Drawdown at any specific point of a well field will be the cumulative drawdown at that location from each well pumping within the area. The individual drawdowns from each PSW well at the five (5) property line observation points (P1 and P3 through P6) are summarized and totaled in Table 3 (nominal pumping rate Q_{ave}) and Table 4 (maximum pumping rate Q_{max}) to give an estimated cumulative drawdown amount at the specified observation point:

Table 3
Groundwater Drawdown at the Property Line Observation Points (ft.) at Nominal Pumping Rates Q_{ave}

PSW Well	P1	P3	P4	P5	P6
PSW-1	3.75	2.52	1.68	0.11	0.09
PSW-3	0.74	0.81	0.78	0.17	0.13
PSW-4	0.40	0.44	0.45	0.31	0.25
PSW-5	0.26	0.28	0.29	0.39	0.32
PSW-6	0.17	0.18	0.19	0.74	0.90
Total	5.32	4.23	3.39	1.72	1.69

Table 4
Groundwater Drawdown at the Property Line Observation Points (ft.) at Maximum Pumping Rates Q_{max} = 10,000 gpm

PSW Well	P1	P3	P4	P5	P6
PSW-1	8.71	5.85	3.92	0.26	0.22
PSW-3	1.80	1.97	1.91	0.40	0.32
PSW-4	0.76	0.82	0.86	0.58	0.48
PSW-5	0.50	0.53	0.55	0.75	0.62
PSW-6	0.32	0.34	0.36	1.40	1.69
Total	12.09	9.51	7.60	3.39	3.33

The greatest groundwater drawdown is estimated to be at the southern property boundary, approximately 12.09 feet with all five (5) wells pumping at the 10,000 gpm, in the vicinity of observation point P1. Assuming an average aquifer thickness of 81.20 feet (Table 2, PSW-1), this results in a net reduction of the available aquifer thickness on the

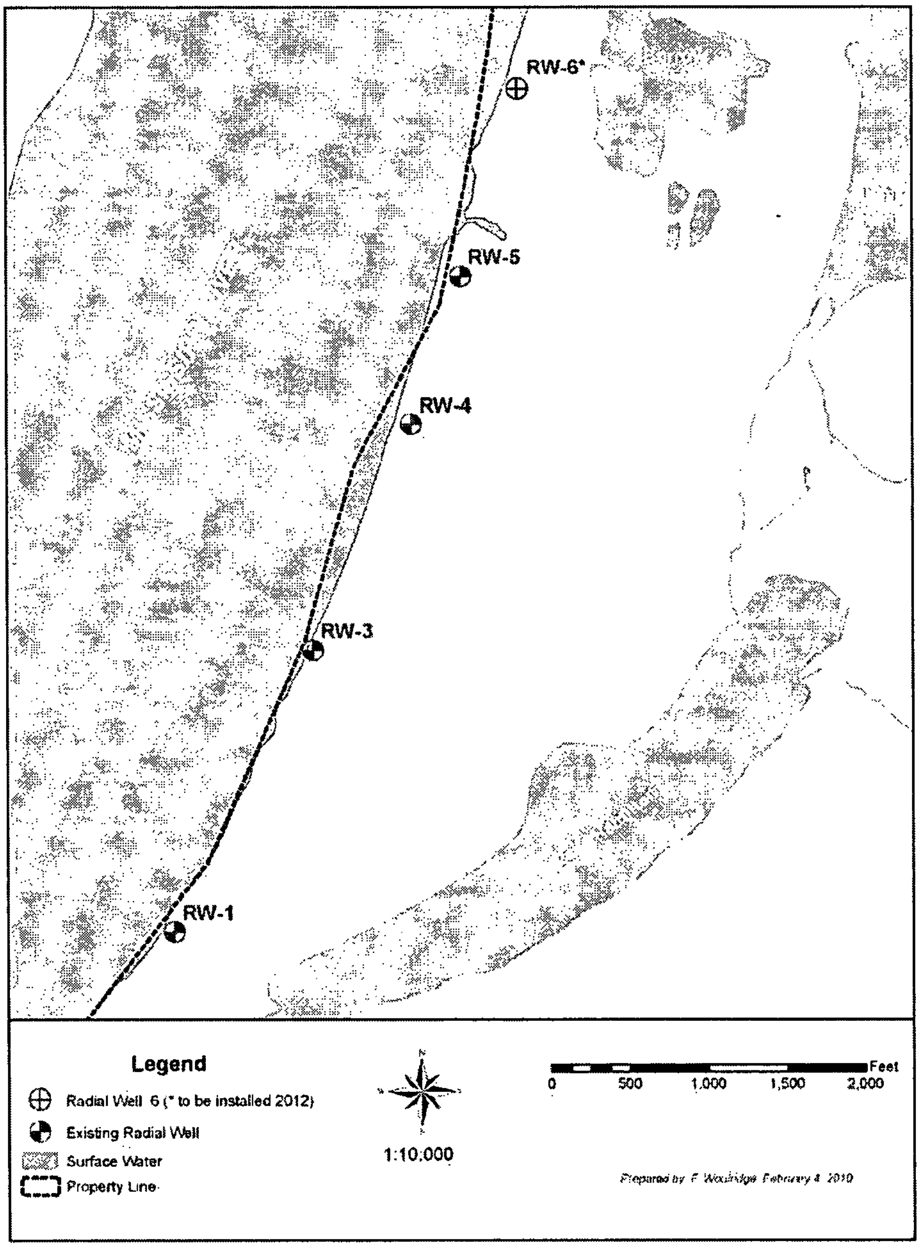
southern property line at P1 of 14.89% [(12.09ft./81.20ft.)*100=14.89%]. If an assumed aquifer thickness of 81.26 ft. exists similar to PSW-5 at Observation Point P5 (See Figure 3) on the GGNS northern property boundary, the reduction of available capacity is 3.39 feet, or 4% (3.39/81.26*100=4.17).

7.0 CONCLUSIONS

Due to the recharge provided by the Mississippi River, groundwater withdrawals from the GGNS PSW well field would not be expected to have an impact on offsite groundwater users west of the river.

Calculation of the groundwater drawdown effects at the GGNS property boundaries, due to pumping all five PSW wells at an assumed maximum flow rate of 10,000 gpm each, resulted in a calculated cumulative drawdown at the closest point on the southern property boundary (observation point P1, Figure 1) of approximately 12.09 feet, or 14.89% of the available aquifer thickness, and 3.39 feet or 4% of available aquifer thickness at northern property boundary.

Figure 1
GGNS Radial Well Locations



Grand Gulf Nuclear Station, Unit 3
COL Application
Part 2, FSAR

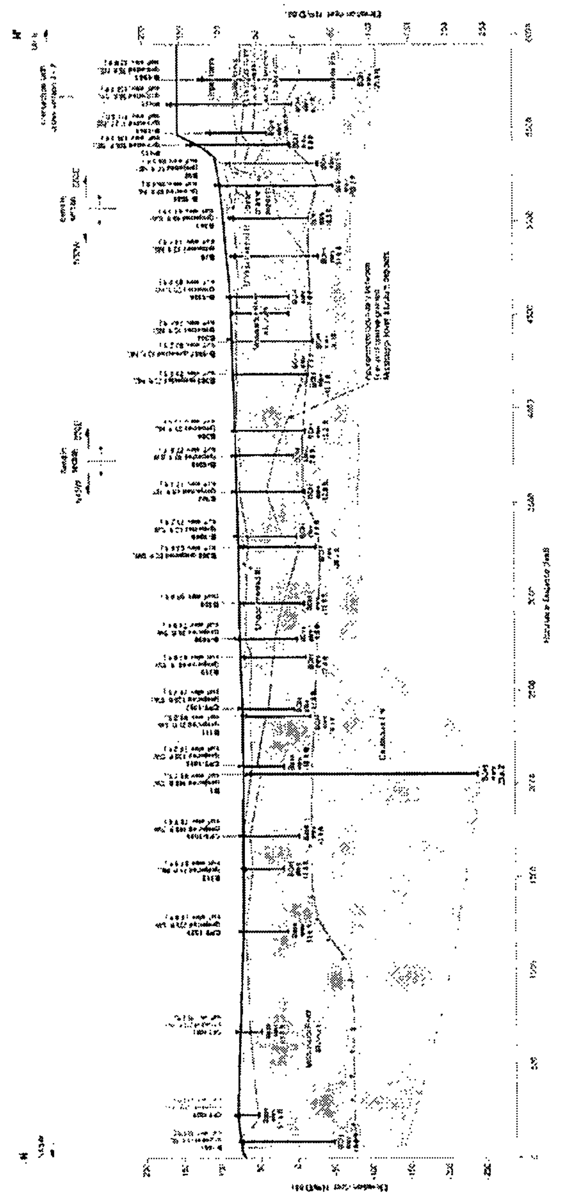
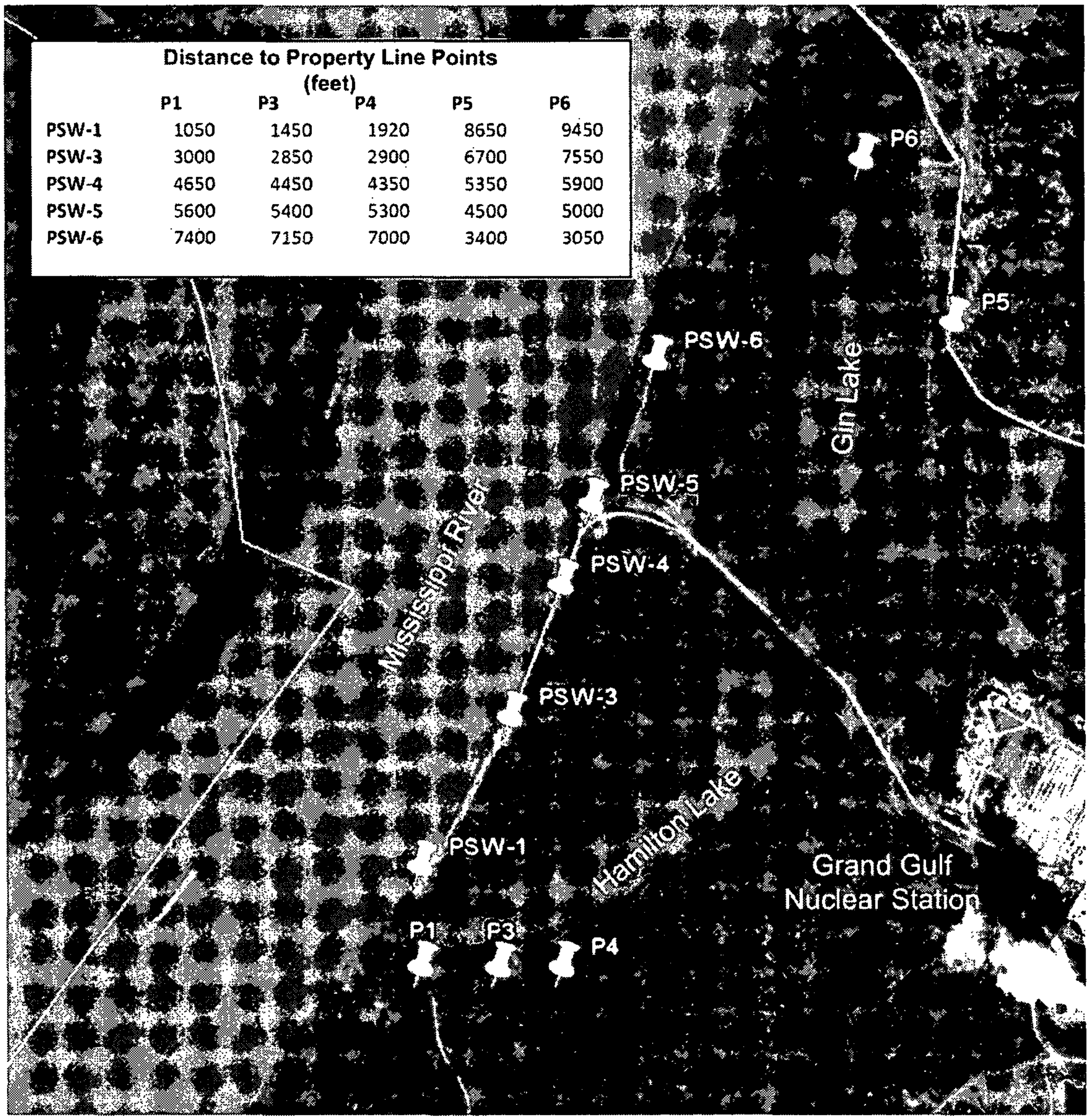


Figure 2.5.4-224. Cross Section H - H'

Revision 0

GGNS COL 2.5-29-A

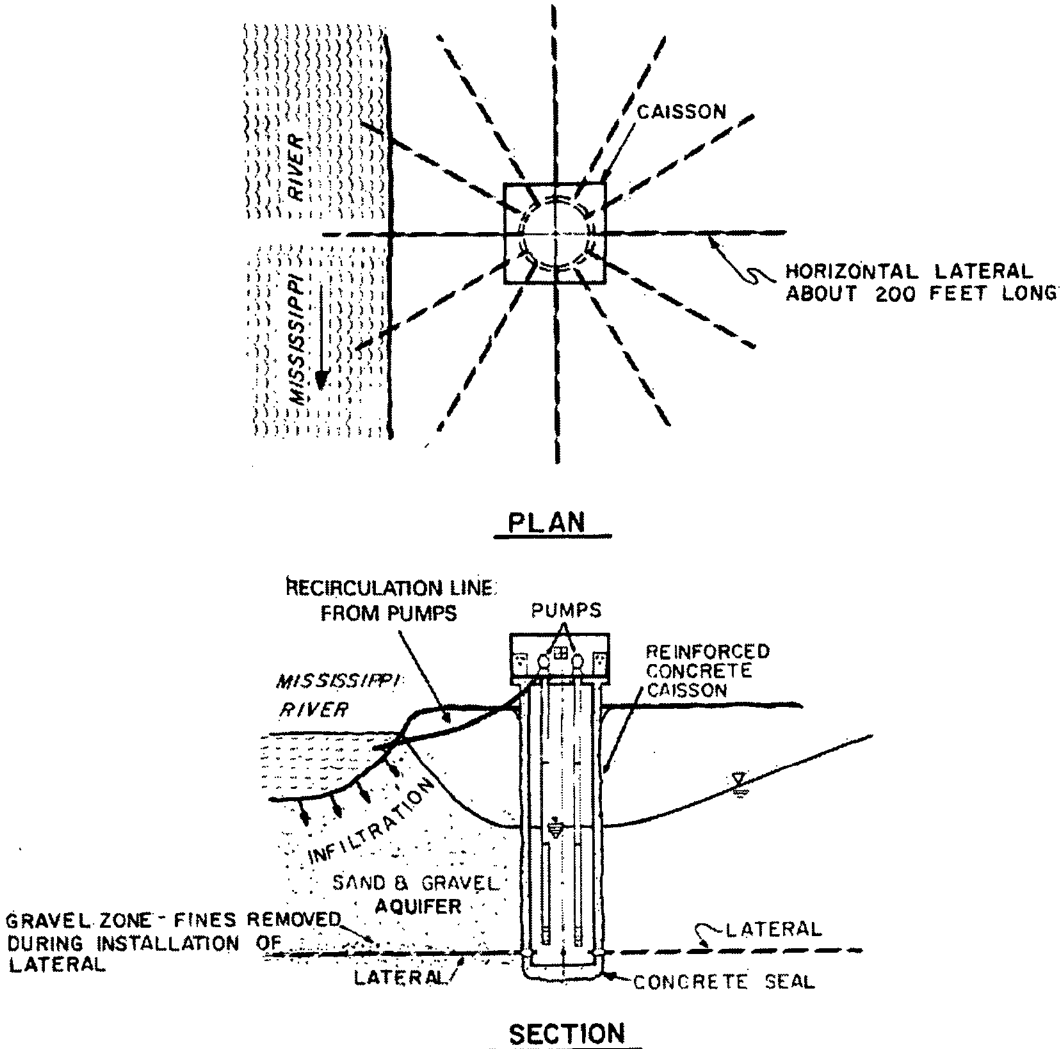
Figure 3
Distance to Property Line Observation Points



Distance to Property Line Points (feet)

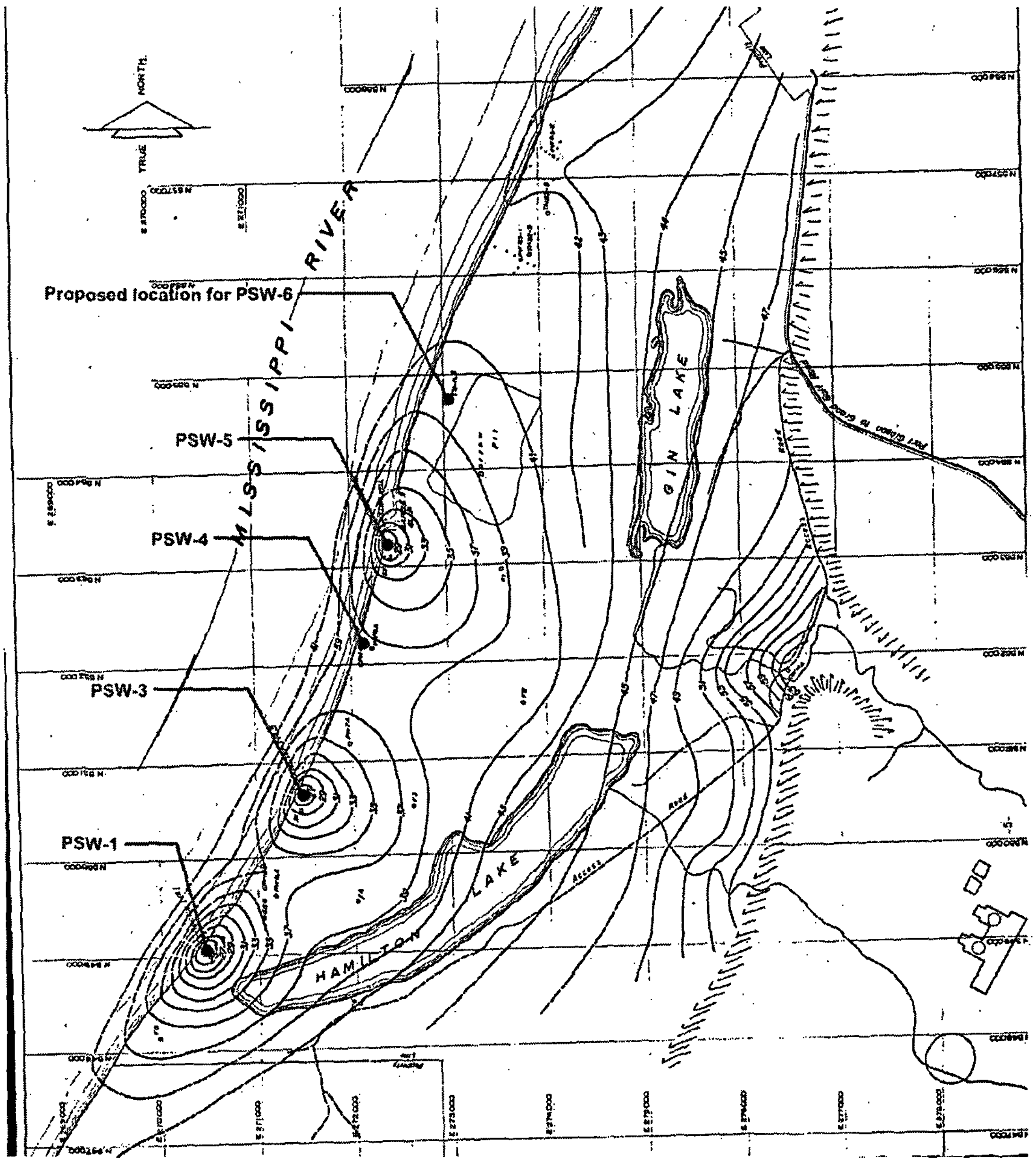
	P1	P3	P4	P5	P6
PSW-1	1050	1450	1920	8650	9450
PSW-3	3000	2850	2900	6700	7550
PSW-4	4650	4450	4350	5350	5900
PSW-5	5600	5400	5300	4500	5000
PSW-6	7400	7150	7000	3400	3050

Figure 4
Radial Well Schematic



N.T.S.

Figure 5
December 9, 1983 Groundwater Potentiometric Surface



(Ranney, 1983)

Attachment 1

GROUND WATER ASSOCIATES, INC.

Prepared for

Entergy Operations, Inc.
Port Gibson, Mississippi

Entergy Operations

EVALUATION OF MEANS FOR

SUPPLYING PLANT SERVICE WATER REQUIREMENTS

GRAND GULF NUCLEAR STATION

June, 1994

A Hydro Group, Inc. Company HYDRO GROUP

Experience has shown that the design life of laterals is generally between 25 and 40 years. Given the site's water quality and production rates, lateral design life of 25 to 30 years should be expected.

New laterals would be oriented in the 180° sector from parallel to the river to toward the river and be constructed of 12-inch ID stainless steel (similar to PSW Well No. 4). Installation of new laterals would generally require 4 to 6 months to complete and normally be performed with the well off line. It is possible that some production from the well could be maintained during the process by manifolding selected laterals, but this would may be add 10 percent to the overall cost.

3.2.4 New Radial Collector Well

In the early and mid 1980's several investigations were conducted to evaluate additional sites for new radial collector wells (Ranney, 1980, 1984). Based upon those reports and the projected PSW supply needs, two sites appear viable for consideration. These sites referred to as Well 2 and Well 6 are shown on Figure 7.

Proposed Well 2 is located midway between PSW Well No. 1 and Well No. 3 while proposed Well 6 is located about 1700 feet north of PSW Well No. 5. Given the better performance and water quality of PSW Well Nos. 4 and 5 and higher projected yield of Well 6 (8000 - 10,000 gpm) and less interference with existing wells, it is recommended that Well 6 be the next site for any new radial collector well. Costs for the development of Well 6 would be slightly higher

Attachment 2

BECHTEL

QUALITY ASSURANCE PROGRAM
CALCULATION COVER SHEET
GRAND GULF NUCLEAR STATION UNIT 1

CALC. NO. C-B361-1

NO. OF SHEETS 36

JOB NO. 9645/15026 DISCIPLINE CIVIL

TITLE
MISSISSIPPI POWER & LIGHT COMPANY
GRAND GULF NUCLEAR STATION UNIT 1

SUBJECT
RADIAL WELLS 1,3,5 – REDUCTION OF MULTIPLE WELL TEST DATA (GEOTECH CALC. G-035)

STATEMENT OF PROBLEM
SEE GEOTECH CALC. COVER SHEET

SAR CHECKED ☒ SAR CHANGE REQ'D. ☐ YES ☒ NO SAR CHANGE REQUEST INITIATED ☐

SOURCES OF DATA
SEE CALC. SHEETS

SOURCES OF FORMULAE & REFERENCES
SEE CALC. SHEETS

COMMITTED PRELIMINARY CALC ☐ FINAL CALC ☒ SUPERSEDES CALC NO. _____

REV. NO.	DATE	DESCRIPTION	ORIGINATOR	CHECKED BY	DATE	APPROVED BY	DATE
0	10/4/85	ORIGINAL CALCS	SEE CALC. SHEETS			J Nogel "R"	7/31/86

GPD-1369 Rev. 12/83

BECHTEL — MISSISSIPPI POWER & LIGHT COMPANY — GRAND GULF NUCLEAR STATION

CALCULATION SHEET

JOB NO.	CALC. NO.	REV. NO.	SHEET NO.
9645	G-035	0	2 of 35

ORIGINATOR	DATE	CHECKED	DATE
D. Middleton	11-16-83	Dennis Beiter	12-1-83

Purpose: I) To calculate the distance to the line source of recharge for radial collector wells 1, 3, and 5 using data from the multiple well test conducted from 10-5-83 to 10-12-83.

II) Part II will involve calculating the theoretical interferences at Collector Pilot Hole (CPH) 2 and 4 and at site B-1, under the conditions present during the multiple well test. The results will be compared to the recorded field measurements.

References:

1) Operations Manual For Radial Water Wells, The Ranney Company, 1981
2) Field Data From Multiple Well Test, 10-5-83 to 10-12-83, Attached.
3) Schaefer, E.J. and Kasar, R., 1965, Graphical Aids For the Solution of Formulas Used In Analyzing Induced Infiltration Aquifer Tests, State of Ohio, DNR, Division of Water, Tech Report No. 6
4) Hydrogeologic Survey For MP&L, Ranney Report, 1975

Formulas Used:

1)
$$T = \frac{527.7\, Q \log\left(\frac{\sqrt{4a^2 + r^2}}{r}\right)}{s}$$
1) Ref. 3 page 3

where: T = Transmissivity (gpd/ft)
Q = Pumping Rate (gpm)
a = distance from pumping well to line of recharge (feet)
r = distance of selected observation point from pumping well (feet)
s = drawdown at selected observation point at distance r from pumping well

Calc. No.: CB861.1 Rev. 0
pg 3

MISSISSIPPI POWER & LIGHT COMPANY
GRAND GULF NUCLEAR STATION

CALCULATION SHEET

JOB NO.	CALC. NO.	REV. NO.	SHEET NO.
9645	G-035	0	4 of 35

ORIGINATOR	DATE	CHECKED	DATE
D. Middleton	11/16/83	Dennis Bennet	12-1-83

Given:

a) Aquifer characteristics for each well

Well	Aquifer Top Ft MSL	Aquifer Bottom Ft MSL	Hydraulic Cond. (K) gpd/ft^2
1	35	-50	2085
3	55	-40	2350
5	67	-45	2500

REF. 1

b) Discharge from each well at time "t". See Section I   Ref. 2

Well	Flow (Q) gpm
1	4300
3	4100
5	5200

Calc. No.: G-B860.1 Rev. 0
pg. 3

BECHTEL — MISSISSIPPI POWER & LIGHT COMPANY, GRAND GULF NUCLEAR STATION

CALCULATION SHEET

JOB NO.	CALC. NO.	REV. NO.	SHEET NO.
9645	G-035	0	5 of 35

ORIGINATOR	DATE	CHECKED	DATE
D. Middleton	11/16/83	Dennis Beuse[?]	12-1-83

I. Calculation of the line source to recharge ("a")

From all the data collected during the multiple well test between 10/5/83 to 10/12/83 one set of conditions must be chosen that are believed to be the most representative ^of steady state conditions^. The parameters chosen to calculate the "a" distance are at 1230 hrs. on 10/9/83.

This time chosen is controlled by conditions in collector 1. Collector 1 had the most variable discharge rates during the test. Therefore any data used must be at a time when the drawdown in collector 1 had become so slow that for all practical purposes steady state conditions can be assumed to exist. Steady state conditions appear to exist at collectors 3 and 5 also. The attached recorder charts, pages 17 through 31, will substantiate this.

In choosing a time reference for calculations, recorder charts from the collector wells and the RWB observation wells were used. There is one RWB observation well for each collector well. RWB wells are located 170 feet from the individual collector well.

The time chosen (1230 hrs on 10/9/83) for this calculation is based on the time when steady state conditions appear to exist simultaneously within each well. As can be seen from the recorder charts these times are:

Well 1 – 1845 hrs on 10/8 to 1300 hrs on 10/9; Well 3 – 1330 hrs on 10/8 to 1300 hrs on 10/9; and Well 5 0945 hrs on 10/8 to 1300 hrs on 10/9.

Because the river remained stable from 10/8 to 10/10 and because all 3 wells achieved steady state conditions for at least 16 hours the calculation for "a" distance will be based on 1230 hr on 10/9/83.

~~Calc. No.: C-B86011 Rev 0~~ 46

CALCULATION SHEET

MISSISSIPPI POWER & LIGHT COMPANY
GRAND GULF NUCLEAR STATION

JOB NO.	CALC. NO.	REV. NO.	SHEET NO.
9645	G-035	0	10 of 35

ORIGINATOR	DATE	CHECKED	DATE
D. Middleton	11-16-83	Dennis Beuse	12-1-83

II Using the given conditions under which the multiple well test was conducted, and the data and procedures given in Geology calculation G-033, the theoretical interference effects will be calculated for CPH-2, CPH-4, and Collector Site 6 (79-1-L2). The results of these calculations will be compared to the recorded field measurements.

Time = 1230 hrs. on 10/9/83 River Level = 41.52 ft.

A) For calculating interference Equation 2 is used.

The interference effects on CPH-2 from Well 1, 3, and 5 will now be calculated.

Well	Distance
1 to 2	1070
3 to 2	940
5 to 2	3530

Distances Scaled from Drawing 2'SKC-2010 Rev A.

Then the theoretical interference effects are:

Well 1 on CPH-2

$$s = \frac{527.7\ Q \log\left(\frac{\sqrt{4a^2 + r^2}}{r}\right)}{Km}$$

and

$$s_i = s + \frac{s^2}{2m}$$

where:

$Q = 4300$ gpm (pg. 4)

$a = 850$ (Calc. G-033)

$m = \frac{[(41.52 - 17.83) - (-50)] + (35 - (-50))}{2} = 79.34$ ft.

$K = 2100$ (Calc. G-033)

$r = 1070$

Calc. No.: C-B861.1, Rev 0
PAGE 10

Attachment 3

THE RANNEY COMPANY

DIVISION OF Layne-NEW YORK COMPANY, INC.

WESTERVILLE, OHIO

MULTIPLE COLLECTOR TEST
and
LATERAL EVALUATION PROGRAM
RANNEY WELLS 1,3,&5

MISSISSIPPI POWER AND LIGHT
GRAND GULF NUCLEAR STATION
GRAND GULF, MISSISSIPPI

DECEMBER 1983

"Creative Water Engineering Since 1933"

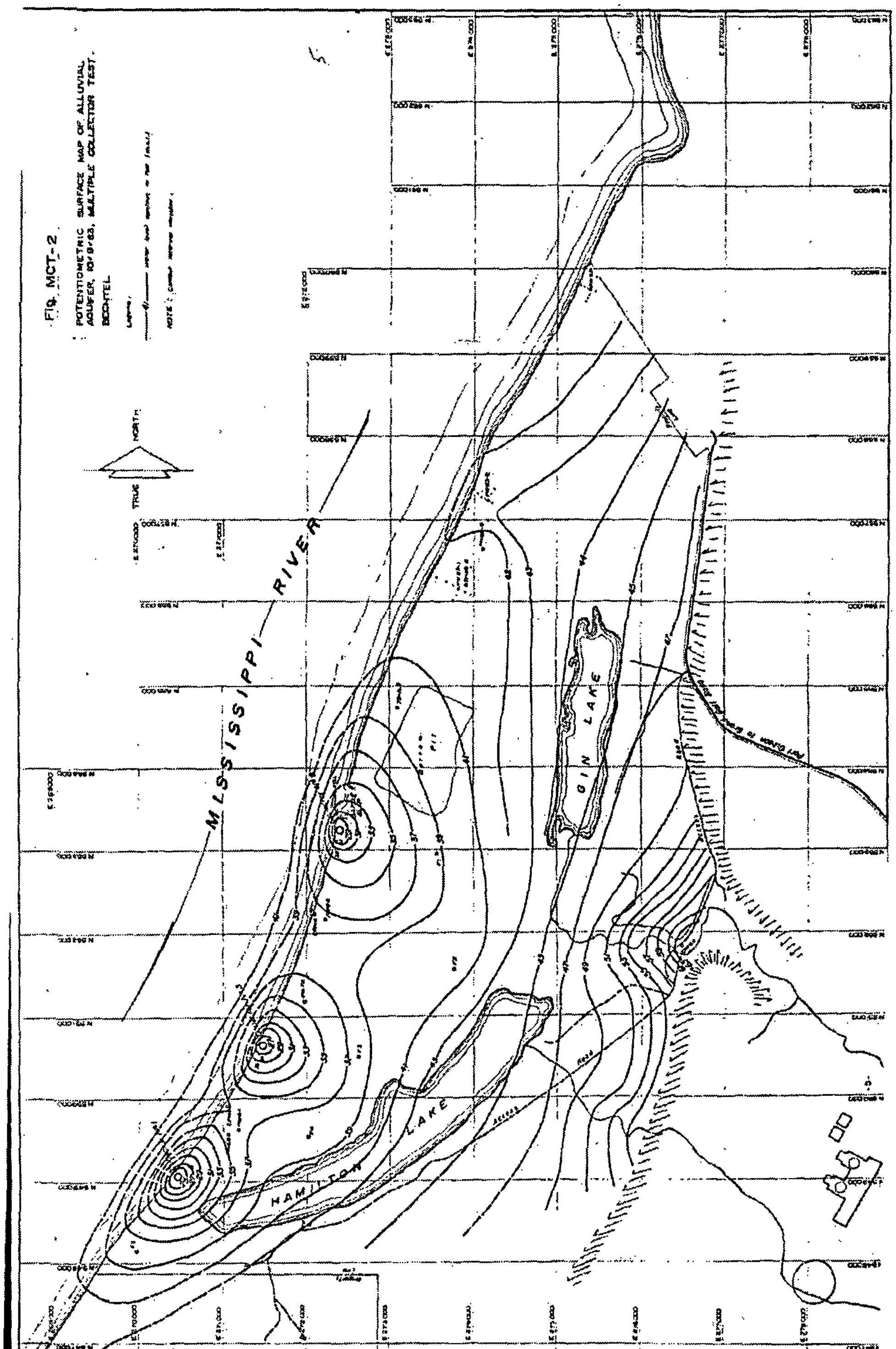


Fig. MCT-2
POTENTIOMETRIC SURFACE MAP OF ALLUVIAL AQUIFER, 10/9/63, MULTIPLE COLLECTOR TEST.
BECHTEL
TRUE NORTH
MISSISSIPPI RIVER
GIN LAKE
HAMILTON LAKE

Yield of Collector 4

The following values and Equation 5 were utilized to determine Collector 4 yield under mean low conditions:

Grade Elevation	75 ft. (MSL)
Elevation Top of Potential Aquifer	65 ft. (MSL)
Elevation Base of Aquifer	-43 ft. (MSL)
Effective Distance to Line Source of Recharge, a	850 ft.
Hydraulic Conductivity, K	1,850 gpd/ft^2
Ground Water Temperature, Test Conditions	62°F
Design Temperature, Mean Low Condition	60°F
Average Lateral Length	208 ft.
Radius of Laterals, r_L	0.5 ft.
Radius of Caisson, r_c	10. ft.
Elevation Centerline of Laterals	-38 ft. (MSL)
Vertical Position of Laterals, Zi	78 ft.
Design Pumping Level	-22 ft. (MSL)
Average Saturated Thickness, m'	52 ft.

$$m' = \frac{83 + 21}{2} = 52 \text{ feet}$$

Therefore,

Attachment 4

HYDRO GROUP®

RANNEY DIVISION

2/89

ANNUAL REPORT

COLLECTOR WELL PERFORMANCE

PSW WELLS 1, 3, 4 AND 5

FOR

SYSTEM ENERGY RESOURCES, INC.
(GRAND GULF NUCLEAR STATION)

OF

PORT GIBSON, MISSISSIPPI

Hydro Group, Inc., 2 North State Street, P.O. Box 729, Westerville, Ohio 43081 (614) 882-3104

Well Performance - PSW Well 4

Figure 16 - Monthly Production Trends illustrates the pumping level in PSW Well 4 as it fluctuates in response to changes in the Mississippi River level and pumping rate. Also shown is the water level in nearby observation well PW8A.

As shown in Figure 16, during 1988 PSW Well 4 was operated at rates ranging from 5350 to 9760 gpm. Pumping levels ranged from a high of +20.5 feet MSL in March (which was coincident with a relatively high river level of +63.0 feet MSL and a low pumping rate of 5350 gpm) and a low of -14.5 feet MSL in August (coinciding with low river level conditions of +35.6 feet MSL).

Figure 17 - PSW Well 4 Monthly Operating Trends presents graphs of Water Temperature, Apparent Specific Capacity and Differential. As shown, during 1988 ground water temperature as measured in PSW Well 4 ranged from a low of 51 degrees Fahrenheit in March to a high of 81 degrees in September and with some moderation, closely mirrored river temperature.

The apparent specific capacity of PSW Well 4 fluctuated considerably during 1988 ranging between 104.9 and 260.6 gpm/ft which may also indicate possible problems in data collection. Differential water level between PSW Well 4 and Observation Well PW8A, with the exception of February, remained at low levels of around 2 to 4 feet/1000 gpm.