Response to Nevada Division of Environmental Protection (NDEP) Comments dated December 13, 2008, regarding *Groundwater Flow Model Calibration Report,* dated November 4, 2008
NDEP Facility ID# H-000688

1. NDEP requests that BRC use consistent units of measurement within the report.

> **Response:** BRC has attempted to balance the use of consistent units with ease of understanding. Historically, certain parameters are typically reported in US literature in certain units (e.g., recharge in terms of inches per year, as opposed to feet per day or some other units). While reporting recharge in feet per day would have been consistent, we believe that it would not have been as user-friendly. In the future, we will attempt to do both – i.e., use customary units for parameters that have such units, while also providing the consistent set of units.

2. Please provide references for all data sources used in the modeling effort.

> **Response:** BRC has attempted to do this. However, please let us know of specific omissions in this regard and we will be happy to provide the data sources in question.

3. Section 3.2.1, Lateral Boundary Conditions, the choice of prescribed flow type boundary assignment over the west, south and east boundaries seems to be less than ideal, given the quality of lateral flow data versus groundwater elevation data along these reaches. Lateral flow data were compiled during the initial water balance stages of modeling, and derived from groundwater elevation data and other data. The groundwater elevation data therefore is the primary measurement, and a specified head boundary would appear to be the clearer choice for boundary assignment type. The initial water budget would then also serve as an independent check on each model simulations water budget output. Also, using the latter approach, the entire length of said boundary is capable of transmitting water, based directly on primary measurement data; the former approach is seen to utilize no flow boundaries, which limit the models ability to transmit water along prescribed boundary reaches. Undesirable effects of the more limiting approach may be negligible if the initial oriented water budget was well posed, or the effects may be more limited to the vicinities of the boundaries. It is not clear that the current approach needs to be changed, however, potential effects of the boundary type must be monitored for during the remainder of the modeling effort.

> **Response:** BRC appreciates the comment. BRC notes, however, that prescribing the hydraulic head can also lead to biased results in an aquifer system such as the Qal where there is little or no saturation across significant portions of the model domain. In addition, the comment about the entire segment being able to transmit water is incorrect. Figure 14 of the report (and Figures R5 and R6 provided with this response to comments) illustrates locations where the Qal is believed to be dry based on monitor well information, so it would incorrect to force water into the model domain across these boundaries by prescribing head in the Qal. BRC could have prescribed head equivalent to that used to determine the groundwater influx; we believe that this would not materially affect the results and conclusions.

4. Section 3.2.1, pg 5, last paragraph on page, regarding the head values for the general head boundary applied along the Las Vegas Wash – what is the source of this data? Also, BRC is encouraged to use primary sources as McGinley and Associates (2003) is a secondary source.

Response: It was BRC's understanding based on prior discussions with the NDEP that referencing the McGinley and Associates (2003) report would be sufficient. In the future, we will use and report the primary references. The hydraulic head for the Las Vegas Wash used as part of the GHB boundary condition for the northern part of the model domain was estimated based on the DEM information, the source of which is referenced below in the response to Comment No. 5. Initial estimates obtained from the DEM were modified as necessary to ensure that successive estimated boundary water levels decreased in the downstream direction between successive GHB model cells.

5. Section 3.2.2, Top Boundary Conditions, what is the source of the land surface data?

Response: The source of the land surface data is 10-meter DEM data obtained from the National Elevation Dataset (NED), which is a product of the USGS EROS Data Center.

6. Section 4.1, pg 12, last paragraph on page, please explain why the PEST code was not used for final model calibration.

Response: BRC conducted the calibration using the manual calibration approach as described in ASTM Standard Guide D-5981. This guide describes both calibration approaches (i.e. manual and "automated" [equivalent to PEST]), but it does not require or recommend one approach over the other. We did complete some PEST runs during the calibration process, but the runs were long and cumbersome to complete, and did not appear to add materially to the results.

7. Section 3.4, Density-Dependent Flow, it is noted that fresh water equivalent heads differ from measured heads by several hundredths of a foot or less. However, these small changes result in changes to the vertical gradients by several factors (a factor four or more in the case of MCF-6A and MCF-6C), which translates directly to effects on vertical flux (again by a factor of four). Since vertical inflow/outflow has been identified as a significant contributor of groundwater flux (approximately 3%), density effects remain a concern. A more thorough treatment of this topic (quantitative) should be anticipated going forward.

Response: BRC respectfully disagrees with this comment. BRC does not believe that the comment accurately interprets the information provided in the calibration report. The fact that BRC states that in many cases equivalent freshwater heads differ from measured heads by a small amount is correctly noted by NDEP, but the subsequent assertion that these small changes result in significant changes ("by several factors") to vertical gradients is incorrect. In the example cited by the NDEP, the reason that the vertical gradient is different by a factor of four is not because of the small difference between measured and equivalent freshwater head in the shallow well MCF-6C, but because of the large difference in measured and equivalent freshwater head for the deep well MCF-6A, which is noted in the report to be about 47 feet. The difference of 47 feet in the deep well is what leads to the vertical gradient change by a factor of four, not the minor difference between measured and equivalent freshwater head in the shallow well. At most locations in the model domain, where the difference in the measured and equivalent freshwater heads is small for both shallow and deep wells (e.g. often several hundredths of a foot or less), there is virtually no difference in the computed vertical hydraulic gradient regardless of whether or not density affects are accounted for.

As noted above, across much of the model domain the difference between observed and equivalent freshwater heads is very small and vertical hydraulic gradients are not affected for all practical purposes. Therefore, part of the 3% of the water budget referred to in the comment occurs as leakage where density differences are inconsequential. As noted above the comment references only the most extreme case, deep well MCF-6A. BRC has now reviewed the zones in the model to determine what the vertical flux is in the areas where density differences are, or may be, significant (Figure R2). The results of this review indicate that 2.6% of the total outflow from the model domain (11,765 ft^3/d) occurs in this region as downward leakage from model layer 2 to the deep UMCf, while 0.3% of total inflow to the model domain (1,370 ft^3/d) occurs as inflow within this region as upward leakage from the deep UMCf to model layer 2. BRC also notes that the vertical flux from the deep UMCf is not a highly sensitive input parameter, as indicated by Figure 23 in the report (general head boundary conductance at base of model layer 2).

8. Section 4.1.1, pg 14, 3rd paragraph, please note that adjustment of lateral groundwater inflow would not be necessary using a specified head approach versus specified flow.

Response: BRC agrees. However, BRC notes that as hydraulic conductivity inside the model domain changes, the simulated inflow at the boundary will change proportionately if the prescribed head approach is implemented. Please also see response to Comment No. 3.

9. Section 4.1.2, pg 16, 1st paragraph, please specify the range in water levels used for the calculation. Also, please note here the average layer 1 aquifer thickness, and discuss in terms of comment to Figure 12 below.

Response: The range in water levels is provided in Table 3 of the report - it is 229.2 ft. Figure R5 is a plot of the saturated thickness of the Qal for 2007 conditions, and Figure R6 is a plot of saturated thickness superimposed on the base of Qal. The average layer 1 saturated thickness is 19.6 ft if wells with zero saturated thickness are included and 22.8 ft if only wells with non-zero saturated thickness are included (only wells listed in Table 4 of the report were used in this calculation). In BRC's view, consideration of an average saturated thickness is of limited value due to wide variations across the site. As indicated in Figure R6, saturated thickness tends to be greater in paleochannels and to the north in the vicinity of Las Vegas Wash and at various potential recharge locations.
BRC could not locate any comments concerning Figure 12 as indicated by the NDEP. Figures R5 and R6 introduced above were provided in response to Comment No. 17.

10. Section 4.1.2, pg 17, last paragraph on page, please explain if adjusting the hydraulic conductivity in the vicinity of the Tronox Athens Road and AMPAC well fields would correct the dewatering issue.

> **Response:** BRC did investigate this issue. However, adjusting hydraulic conductivity did not correct the dewatering issue.

11. Section 4.2, pg 18, last paragraph on page, the NDEP is not sure the explanation for the simulation of historical groundwater elevations bears any relationship to future conditions; *i.e.*, recharge and rising water table due to residential/commercial development.

> **Response:** Simulation of historic conditions was not conducted in lieu of future-conditions simulation. The reasoning behind looking at historical conditions using the model was discussed in detail in the model work plan – mainly to provide additional confidence in the modeling approach. Conducting model calibration to alternate hydrologic conditions where possible is good standard practice, as noted in ASTM Standard Guide D-5981, Item 6.5.

12. Section 4.2, pg 19, 1st paragraph, please explain why the adjustments were not made to reduce the groundwater outflows in areas not indicated on the aerial photography.

> **Response:** The requested adjustments were not made because there was no hard (i.e., defensible) data on which to base the adjustments. Boundary flows for the historical scenario are particularly uncertain (as are observed hydraulic heads), and any adjustments would have been dependent on weak assumptions, and therefore, questionable. BRC did not feel that any fundamental improvement to the model would have resulted.

13. Section 4.2, pg 20, 1st paragraph, please explain if adjusting the hydraulic conductivity in the seep area would correct the issue with regards to simulated groundwater elevation occurring below land surface.

> **Response:** Correction of this issue would require a significant lowering of hydraulic conductivity, which is not consistent with the observed field data in this area. The seep occurs in a paleochannel area.

14. Section 5, how do the sensitivity analysis results tie back into the model development? Are the most sensitive parameters also the most, or least, well known? Does the analysis qualify the data to any degree?

> **Response:** BRC has provided the available data regarding each input parameter in the calibration report in order for the reader to assess the sensitivity of a particular parameter. While more data would always be better, BRC believes that we have reasonably good data for the CoH

Northern RIBS (second most sensitive parameter). BRC also believes that hydraulic conductivity coverage is reasonable.

15. Figure 4, it is hard to rectify the specified flow boundary placements versus the groundwater elevation contours shown in Figure 6. Also no corresponding historical groundwater elevation contours were presented for the historical scenario. A separate figure is recommended for historical and current scenarios, including the superimposed corresponding groundwater elevation contours for each period (which were used to estimate flux across depicted boundaries).

Response: Figures 4 and 6 are not intended to correspond. Figure 4 illustrates boundary conditions for model layer 1 (Qal), while Figure 6 illustrates a current condition contour map for the upper portion of the UMCf, represented by model layer 2. Figure 6 can be compared to Figure 5, for which there is a good correspondence of the boundary selection. In addition, more details on the boundary parameters are provided in the Revised Technical Memorandum referenced as DBS&A (2008a) in the modeling report, and detailed information provided in the Revised Technical Memorandum was not (for the most part) replicated in the modeling report.

16. Figure 8, please include traces of the paleochannels on this figure.

Response: The requested figure is attached as Figure R1.

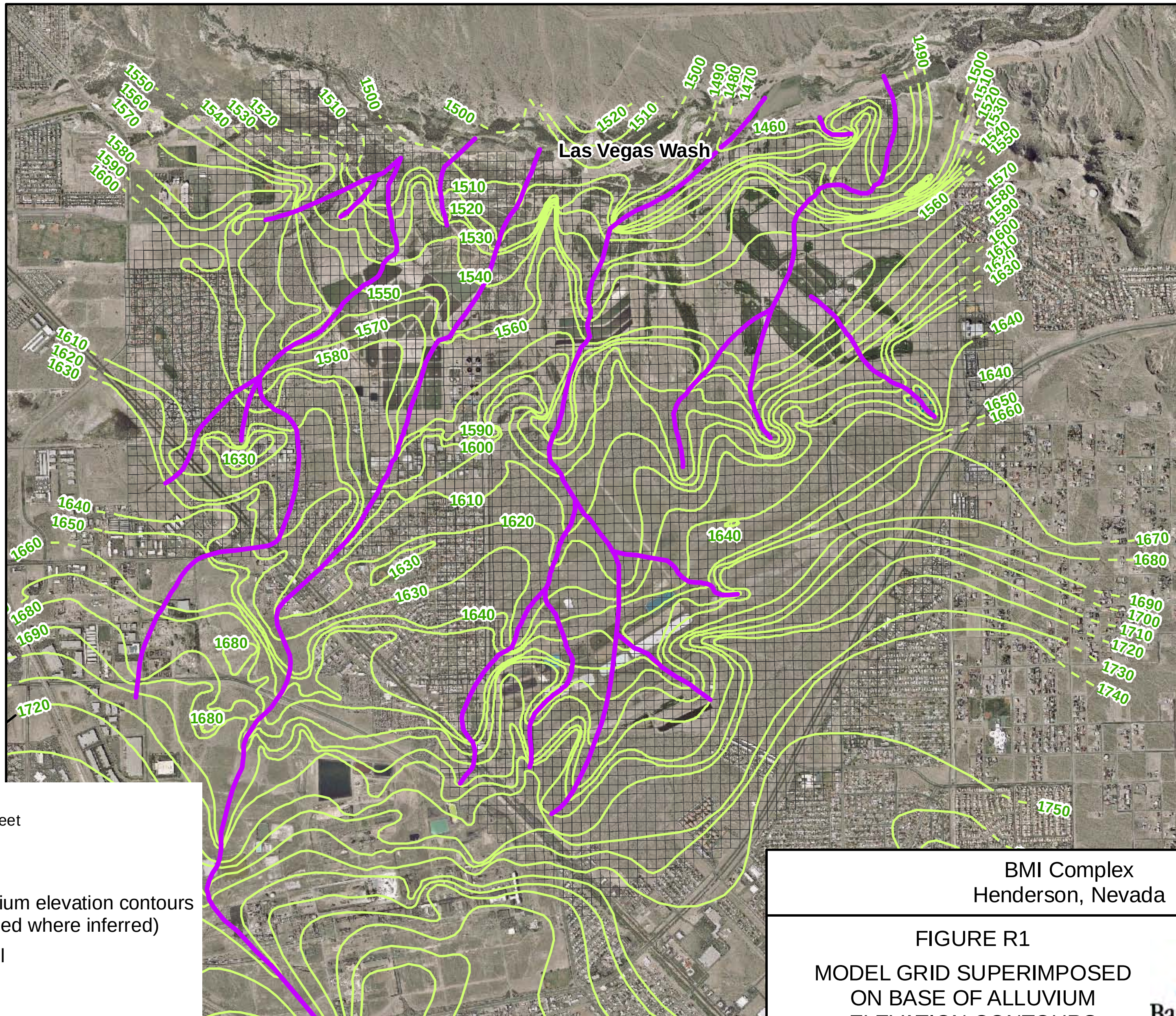
17. Figures 13 and 16, the NDEP notes that the improved MAE and RMSE statistical measures over the August 7, 2008 presentation. Additional figures are requested, corresponding to these figures, showing head residuals labeled on a base map of target wells. Please also include on the Layer 1 figure contours of aquifer thickness. This will be helpful in terms of identifying areas of inordinately high residuals with respect to aquifer thickness and areas of concern for predictive scenarios. If the highest residuals are proximal to areas of relatively thin aquifer, or proximal to areas of greatest concern for water table rise in predictive scenarios, then the model may not be achieving its objective.

Response: The requested figures are attached as Figures R3 through R8. A brief description of each figure follows:

a. Figure R3 - Location of observation wells for model layer 1 used in model calibration.
b. Figure R4 - Map of residual between observed and simulated water levels for layer 1.
c. Figure R5 - Map of Qal observed saturated thickness.
d. Figure R6 - Map of Qal observed saturated thickness superimposed on base elevation of Qal and delineated paleochannels.
e. Figure R7 - Location of observation wells for model layer 2 used in model calibration.
f. Figure R8 - Map of residual between observed and simulated water levels for layer 2.

A contour map of Qal saturated thickness was not constructed as requested by NDEP because the available information is insufficient to construct such a map across large portions of the site. The available data clearly illustrate larger saturated thickness in paleochannels, and reduced (and in many areas zero) saturated thickness outside of paleochannels (Figure R6). Note that the figures provided with this response are based on the observation well information used for the current period (2007) model calibration, which are listed in Table 4 of the groundwater model report.

Additional well information related to the delineation of areas where the Qal is believed to be dry provided in Figure 14 of the modeling report is also posted on Figures R5 and R6. Although these additional points from Figure 14 were used to compare simulated regions of dry Qal with observed regions of dry Qal, they were not included in the model calibration statistics. If these points were included in the model calibration statistics, the mean error, mean absolute error and root mean squared error would be further reduced.



Source: Aerial photograph, April 2004

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FIGURE R1

MODEL GRID SUPERIMPOSED ON BASE OF ALLUVIUM ELEVATION CONTOURS

Basic Remediation COMPANY

Prepared by: DBS&A MW

Date 1/14/09

S:/PROJECTS/BRC/ES09.0008_GW_MODEL_PREDICTIVE_SIM/GIS/MXDS/REPORT_FIGURES_01-09/FIG-R1_MODEL_GRID_SUPERIMPOSED_ON_BASE_ALLUVIUM_ELEV_CONT_WITH_PALEOCHANNELS.MXD

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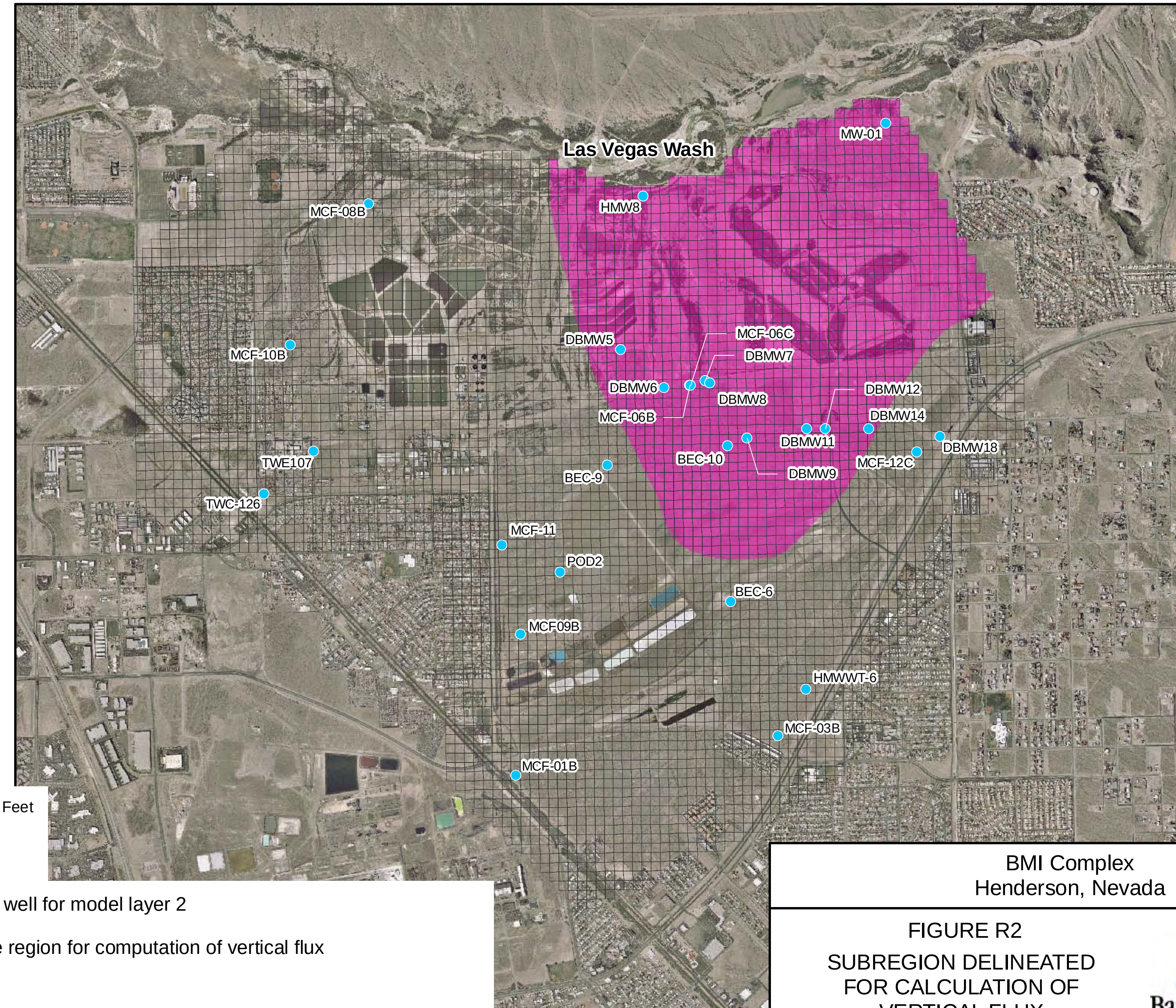

Explanation

ID Observation well for model layer 2

Approximate region for computation of vertical flux

Model grid

Source: Aerial photograph, April 2004

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FIGURE R2
SUBREGION DELINEATED FOR CALCULATION OF VERTICAL FLUX

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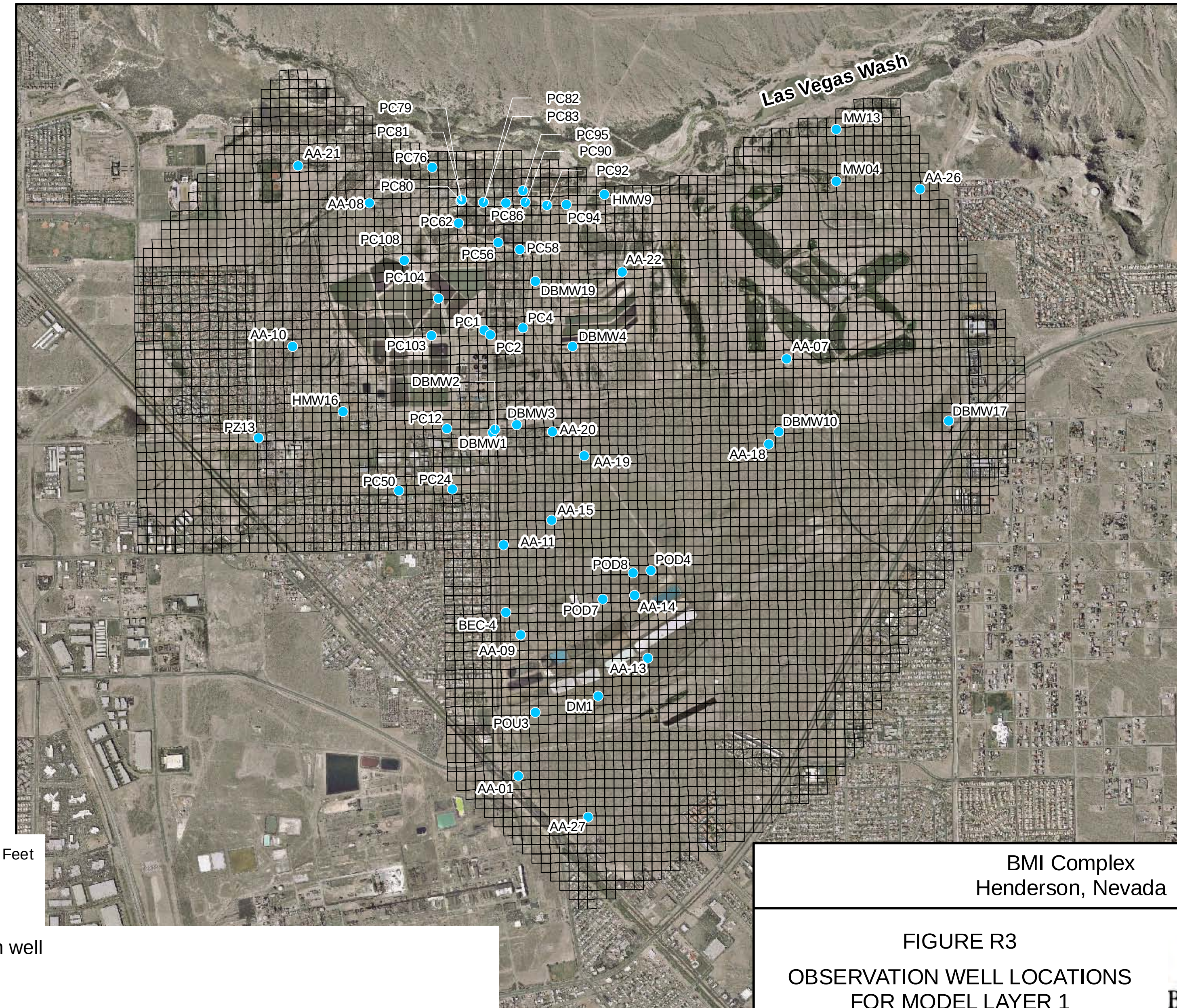
Prepared by: DBS&A MW

Date 01/15/09

S:/PROJECTS/BRC/ES09.0008_GW_MODEL_PREDICTIVE_SIM/GIS/MXDS/REPORT_FIGURES_01-09/FIG-R2_SUBREGION_DELINEATED_CALC_VERTICAL_FLUX.MXD

S:/PROJECTS/BRC/ES09.0008_GW_MODEL_PREDICTIVE_SIM/GIS/MXDS/REPORT_FIGURES_01-09/FIG-R3_OBSERVATION_WELL_LOCATIONS_MODEL_LAYER_1.MXD



N

0 1,750 3,500 Feet

Explanation

ID Observation well

Model grid

Source: Aerial photograph, April 2004

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FIGURE R3

OBSERVATION WELL LOCATIONS
FOR MODEL LAYER 1

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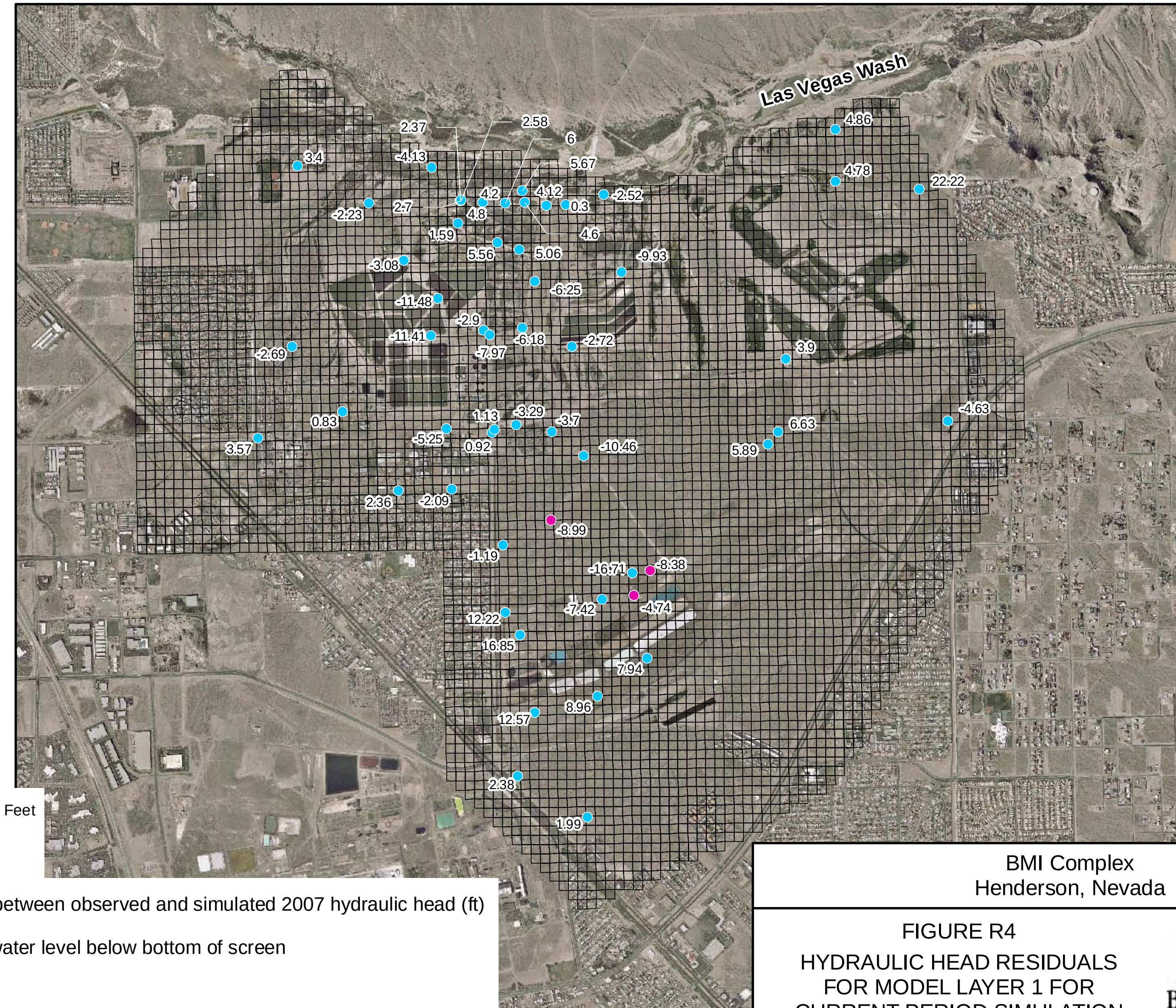
Date 01/15/09

S:/PROJECTS/BRC/ES09.0008_GW_MODEL_PREDICTIVE_SIM/GIS/MXDS/REPORT_FIGURES_01-09/FIG-R3_OBSERVATION_WELL_LOCATIONS_MODEL_LAYER_1.MXD

Figure R3

S:/PROJECTS/BRC/ES09.0008_GW_MODEL_PREDICTIVE_SIM/GIS/MXDS/REPORT_FIGURES_01-09/FIG-R4_LOC_OBSER_MODEL_LAYER_1_HYD_HEAD_RESIDUALS_DATA_CUR_PER_SIM.MXD



N

0 1,750 3,500 Feet

Explanation

2.38 Difference between observed and simulated 2007 hydraulic head (ft)

Observed water level below bottom of screen

Model grid

Source: Aerial photograph, April 2004

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FIGURE R4

HYDRAULIC HEAD RESIDUALS FOR MODEL LAYER 1 FOR CURRENT PERIOD SIMULATION

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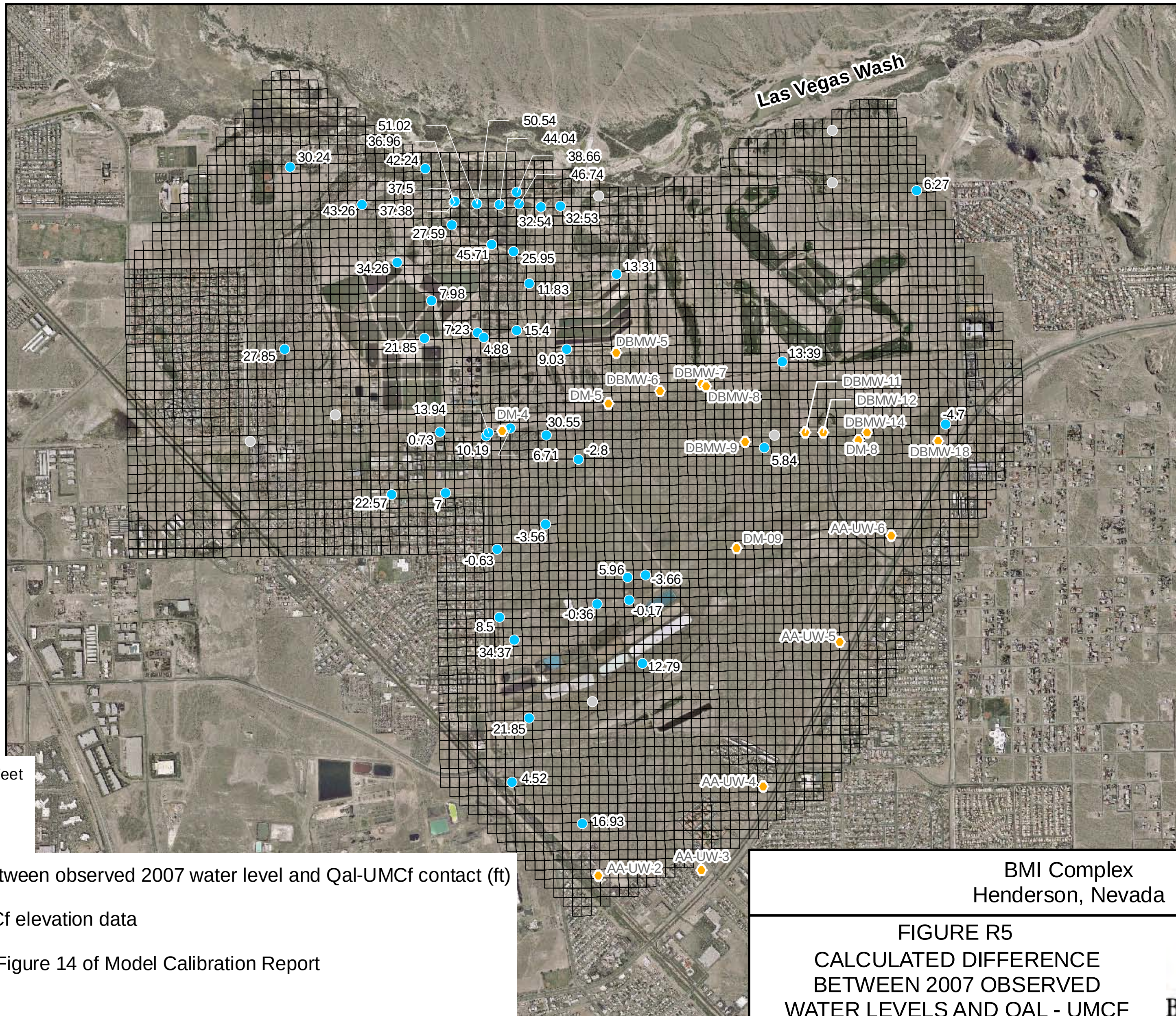
Figure R4

S:/PROJECTS/BRC/ES09.0008_GW_MODEL_PREDICTIVE_SIM/GIS/MXDS/REPORT_FIGURES_01-09/FIG-R5_LOC_OBSER_MODEL_LAYER_1_WATER_THICKNESS_ABOVE_UMCF.MXD



Explanation

- 4.52 Difference between observed 2007 water level and Qal-UMCf contact (ft)
- No Qal - UMCf elevation data
- Qal dry from Figure 14 of Model Calibration Report
- Model grid

Source: Aerial photograph, April 2004

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FIGURE R5
CALCULATED DIFFERENCE
BETWEEN 2007 OBSERVED
WATER LEVELS AND QAL - UMCF
CONTACT FOR MODEL LAYER 1

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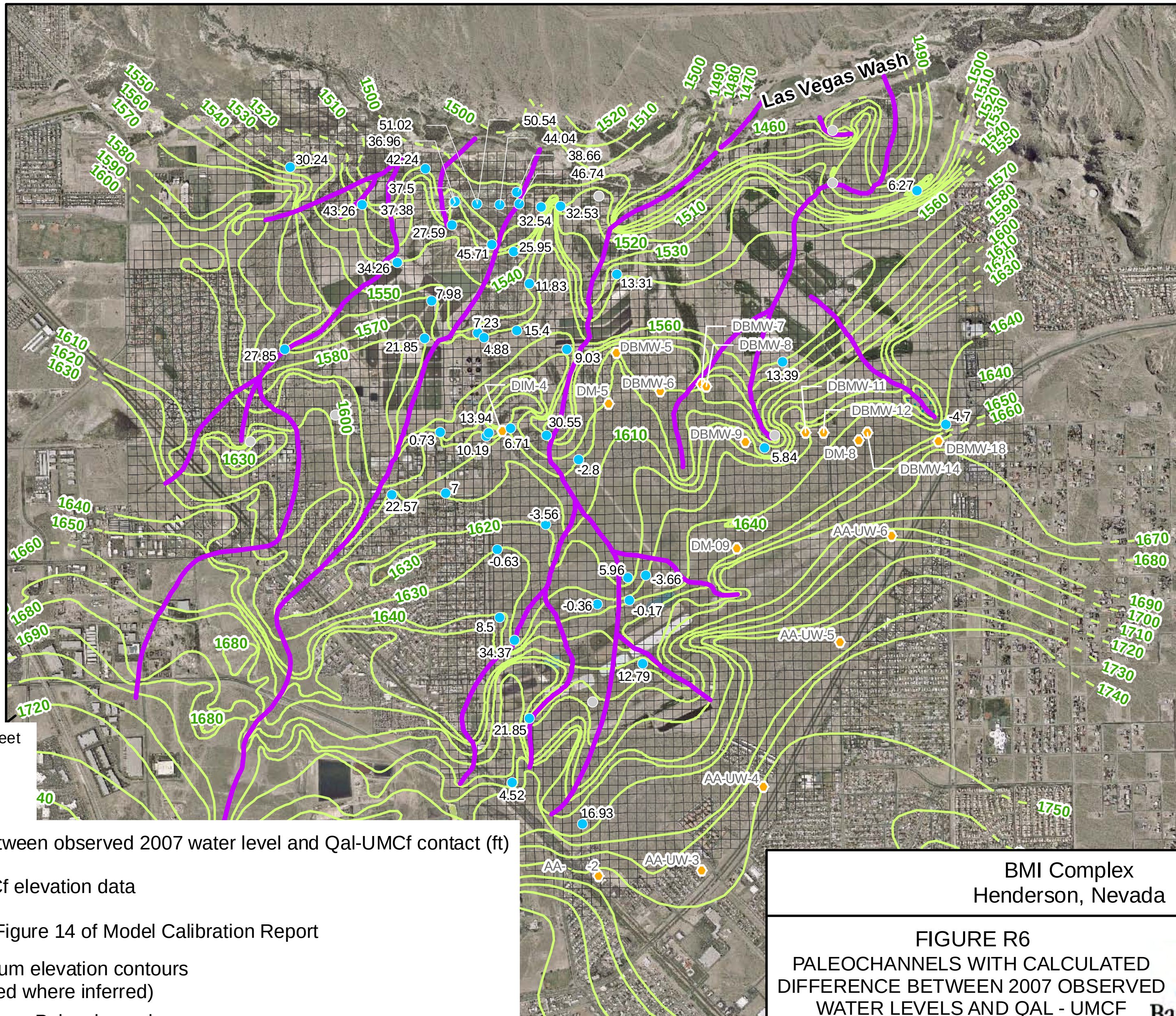
Figure R5



N

0 1,750 3,500 Feet

Explanation

- Difference between observed 2007 water level and Qal-UMCf contact (ft)
- No Qal - UMCf elevation data
- Qal dry from Figure 14 of Model Calibration Report
- Base of alluvium elevation contours (ft msl) (dashed where inferred)
- Paleochannel
- Model grid

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FIGURE R6
PALEOCHANNELS WITH CALCULATED DIFFERENCE BETWEEN 2007 OBSERVED WATER LEVELS AND QAL - UMCF CONTACT FOR MODEL LAYER 1

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DBS&A MW	1/15/09	S:/PROJECTS/BRC/ES09.0008_GW_MODEL_PREDICTIVE_SIM/GIS/MXDS/REPORT_FIGURES_01-09/FIG-R6_PALEOCHANNELS_WITH_CALC_DIFF_2007_WL_AND_QAL-UMCF.MXD

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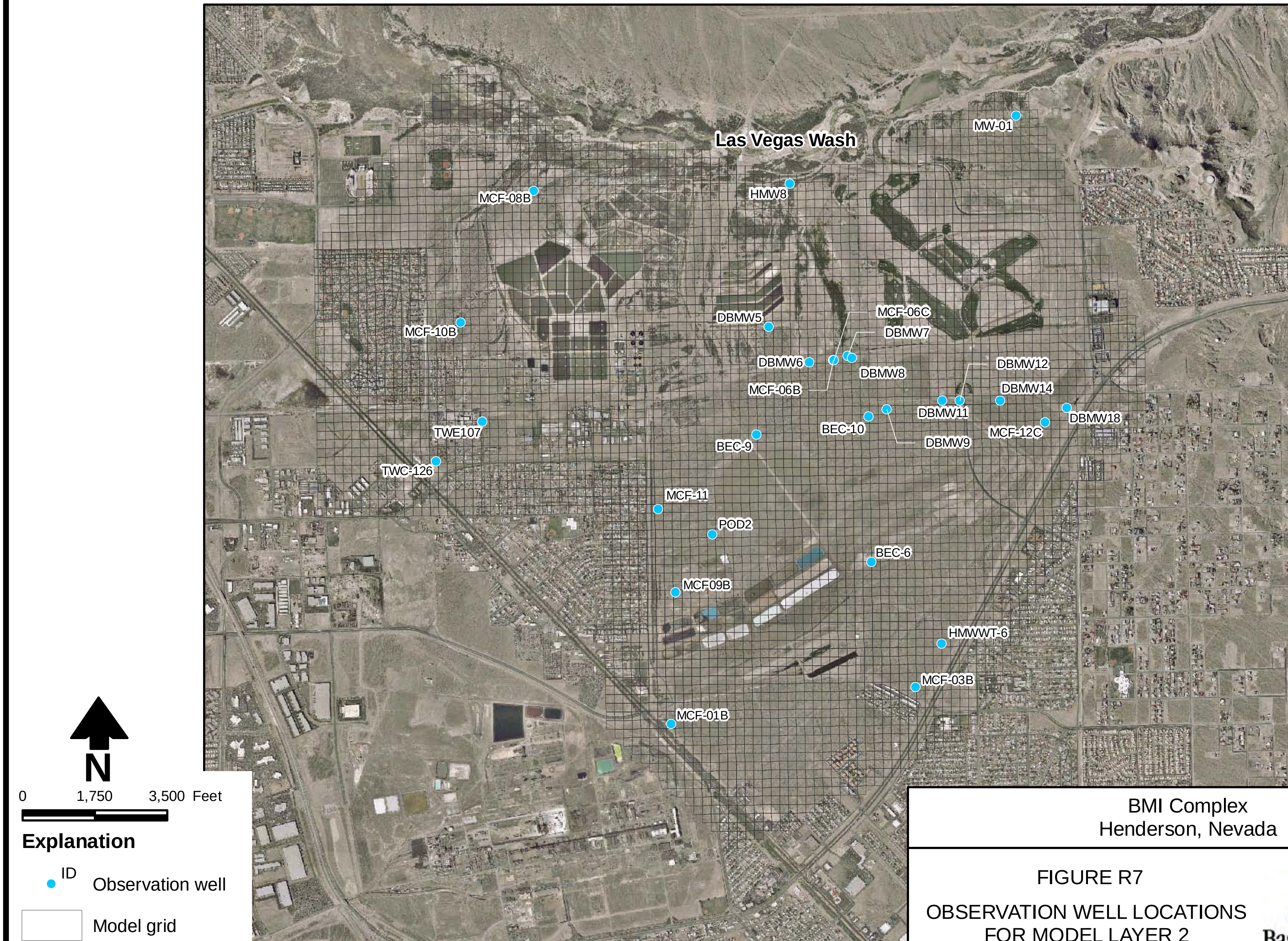
Figure R6

S:/PROJECTS/BRC/ES09.0008_GW_MODEL_PREDICTIVE_SIM/GIS/MXDS/REPORT_FIGURES_01-09/FIG-R7_OBSERVATION_WELL_LOCATIONS_MODEL_LAYER_2.MXD



Source: Aerial photograph, April 2004

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FIGURE R7
OBSERVATION WELL LOCATIONS
FOR MODEL LAYER 2

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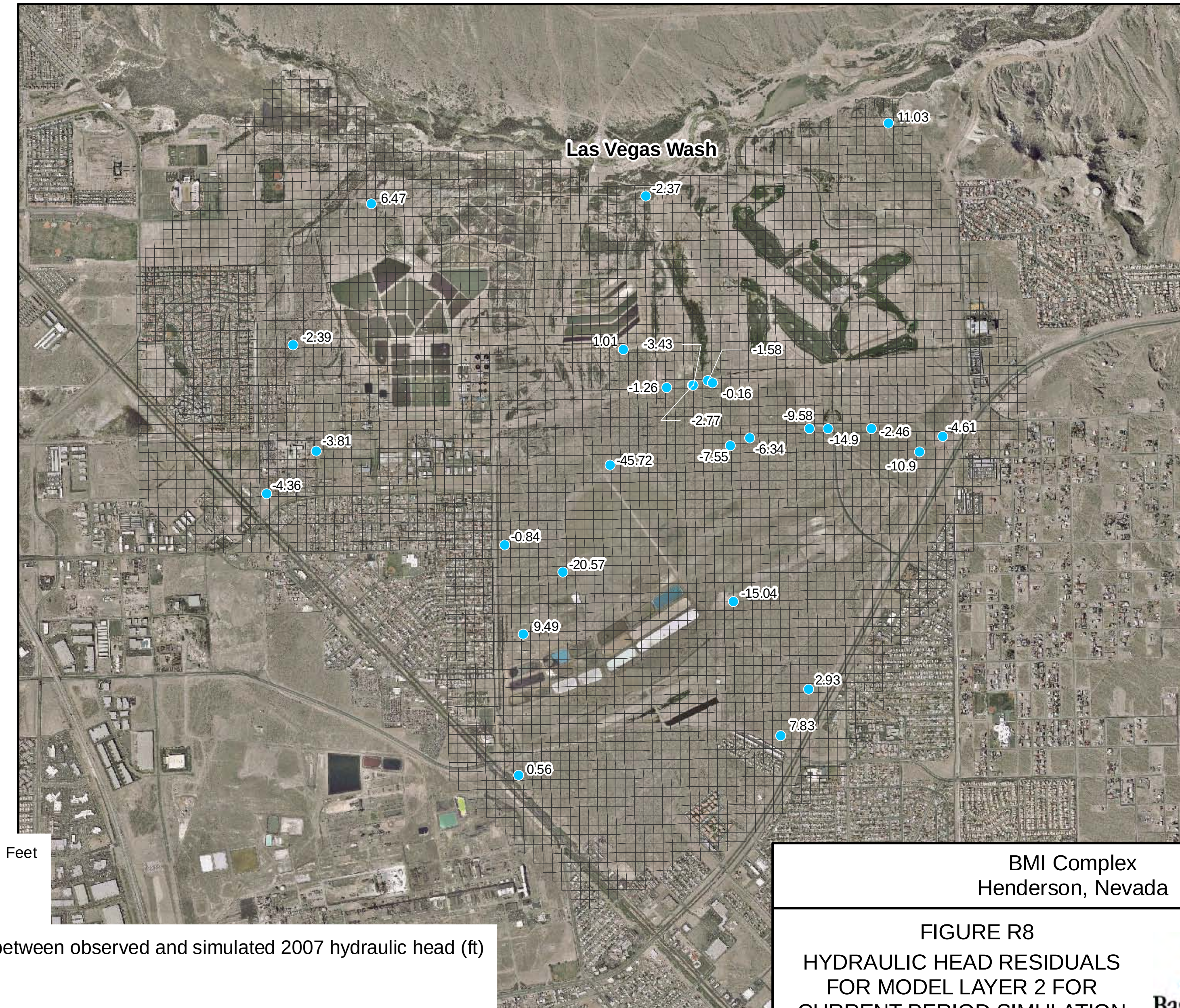
DBS&A	MW	01/15/09	S:/PROJECTS/BRC/ES09.0008_GW_MODEL_PREDICTIVE_SIM/GIS/MXDS/REPORT_FIGURES_01-09/FIG-R7_OBSERVATION_WELL_LOCATIONS_MODEL_LAYER_2.MXD

Figure R7

S:/PROJECTS/BRC/ES09.0008_GW_MODEL_PREDICTIVE_SIM/GIS/MXDS/REPORT_FIGURES_01-09/FIG-R8_LOC_OBSER_MODEL_LAYER_2_HYD_HEAD_RESIDUALS_DATA_CUR_PER_SIM.MXD



Explanation

Difference between observed and simulated 2007 hydraulic head (ft)

Model grid

Source: Aerial photograph, April 2004

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FIGURE R8
HYDRAULIC HEAD RESIDUALS FOR MODEL LAYER 2 FOR CURRENT PERIOD SIMULATION

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Figure R8