NRC PHASE II REVIEW OF DOE STUDY PLAN FOR REGIONAL HYDROLOGIC SYNTHESIS AND MODELING (STUDY PLAN NUMBER 8.3.1.2.1.4, REV. 0)

by

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INTRODUCTION

Background

During the Phase I review (memo from Federline to Holonich, March 16, 1992) of the study plan, it was concluded that the plan qualified for a Phase II (detailed technical) review. The study plan meets three of NRC's criteria (1, 2, 3) for detailed review of study plans. Criterion 1 relates to key site-related issues, and Criterion 2 pertains to NRC open items. Criterion 3 relates to unique analysis methods that do not have a supportive history in licensing. Accordingly, a Phase II review has been performed.

No new data will be collected under this study plan. Rather, work under the plan consists of "synthesizing" existing and new hydrogeologic data to construct regional groundwater models. A key study plan that is designed to provide data for this work is DOE (1991), "Characterization of the Regional Groundwater Flow System." The staff did not perform a Phase II review for the DOE (1991) study plan, but in reviewing this study have chosen to comment on those data collection activities that directly support the development and calibration of regional groundwater models.

Review Objectives

The Phase II review was based on the Review Plan for NRC Staff Review of DOE Study Plans and Procedures (NRC, 1990). One of the purposes of a detailed technical review is to evaluate the degree to which the proposed study will enable the DOE to collect the information needed for licensing. A detailed review should also evaluate whether there is apparent progress toward resolution of any NRC open items.

DETAILED TECHNICAL REVIEW

The principal objectives of the study plan "Regional Hydrologic Synthesis and Modeling" are as follows: (1) synthesize all existing and new site and regional hydrogeologic data into conceptual models of regional and subregional groundwater flow, and (2) develop numerical models of the groundwater flow systems based on the conceptual models.

The study plan has four activities: (1) conceptualization of regional flow systems; (2) subregional 2-D areal hydrologic models; (3) subregional 2-D cross-sectional modeling; and (4) regional 3-D hydrologic modeling. DOE has already achieved significant progress in activities 1, 2, and 4. Since the early 1980s, USGS staff have performed regional and subregional 2-D modeling of hydrogeology in southern Nevada. As described in the study plan, a preliminary 3-D model has also been produced.

Documentation of Well Data

Previous reports on regional modeling in the Yucca Mountain region do not provide sufficient information about the selection and documentation of wells and boreholes used to obtain hydraulic heads (and other data) for model calibration. For example, Czarnecki and Waddell (1984) provide (in their Table 5) Nevada state coordinates (northing and easting) for nodes in their model grid that are nearest to well locations. But it would be better to have coordinates for the wells instead of the model nodes. Hydraulic heads are provided, along with data sources. However, of the five data sources listed, only two are published reports, and only one of these (Walker and Eakin, 1963) lists tabular information about wells in the region. Walker and Eakin (1963) is an acceptable reference, but it is almost 30 years old and the well locations are given in township and range coordinates rather than the currently used Nevada State plane coordinate system. This reference includes data from springs and more than 140 wells in the Amargosa Desert. It includes two wells in the vicinity of Yucca Mountain (Crater Flat) but does not include data from the Nevada Test Site. Waddell (1982) cited Thordarson and Robinson's (1971) inventory of over 6000 wells and springs within a 100-mile radius of the Nevada Test Site, a reference that is more than 20 years old.

It is recognized that regional modeling studies rely heavily on existing data sources such as irrigation wells, farm and ranch wells, and mining exploration boreholes. These wells and boreholes were not designed for the scientific collection of groundwater data, and thus details of their construction were usually not well documented in the past. Nevertheless, such wells and boreholes are indispensible for calibrating regional models, and known details about such data sources should be documented. Such wells and boreholes are generally privately owned and may become inaccessible to future investigators; therefore, they should be documented to the extent practicable. Also, groundwater overdrafts have occurred at various places in southern Nevada, resulting in localized lowering of the water table. It is important to document such information in order to better support any current and future groundwater modeling work (see attached comment 1).

A key study plan that supports this study is DOE (1991), which addresses regional hydrogeologic characterization. Based on page 3.2-20 of DOE (1991), it appears that a scientific notebook procedure is being developed for regional reconnaissance of wells, springs, etc. This procedure should clearly specify the types of information needed to adequately document calibration wells. The NRC staff considers that it is appropriate to comment on data being collected under a related study because of the importance of that data in constructing and calibrating the models developed under this "synthesis" study.

Modification of Existing Models

The study plan needs to be updated with respect to available literature on alternate conceptual models for the regional groundwater system. The study plan does not adequately describe the approach for modifying existing conceptual models based on new hydrogeologic data (see attached comment 2).

During the 1980s, the USGS performed a considerable amount of regional modeling for the area of southern Nevada. This work was documented in published reports, papers, and abstracts, including Waddell (1982), Czarnecki and Waddell (1984), and Czarnecki (1985). These documents are cited in the subject study plan. However, the study plan does not cite a key reference (Czarnecki, 1989) that presents potentiometric data from the Greenwater Range and a new conceptual model of groundwater flow.

Czarnecki (1989) presented a new (or alternate) conceptual model of subregional groundwater flow. This new conceptualization was based on the acquisition of potentiometric data in the Greenwater Range, showing the probable presence of a groundwater flow divide beneath this range. Overall, the potentiometric data suggest the need for model recalibration and revision of the model boundaries of Czarnecki and Waddell (1984) and Czarnecki (1985). Figure 1 gives a new interpretation of the potentiometric surface based on the presence of a hypothesized flow divide beneath the Greenwater Range and the Funeral Mountains.

In Czarnecki's 1985 model, Franklin Lake Playa and Furnace Creek Ranch serve as discharge areas for the water table aquifer. On the basis of the data from the Greenwater Range, Franklin Lake

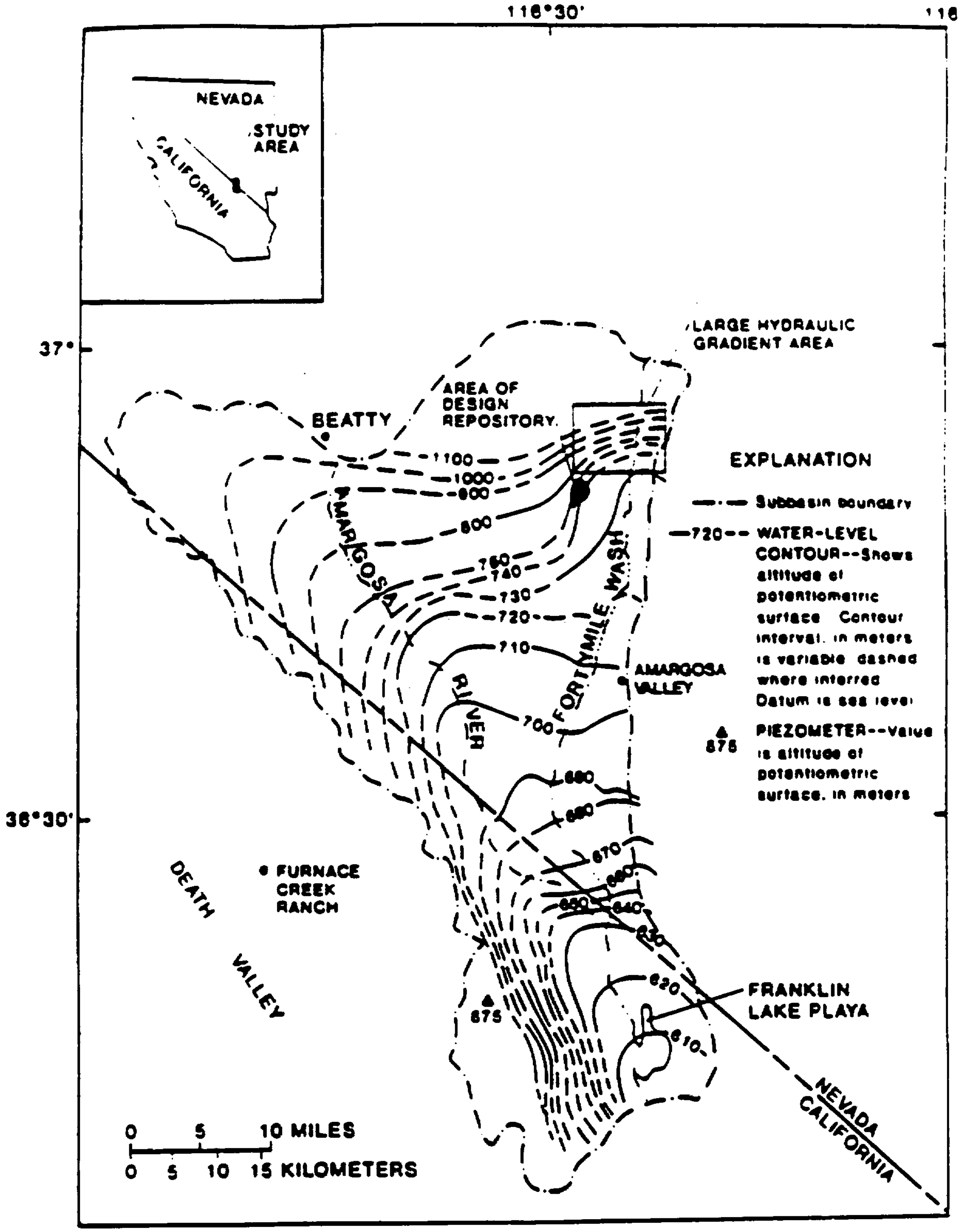

Figure 1. Subregional potentiometric surface (Czarnecki, 1989). (DOE,1991)

Playa may serve as the principal discharge area for the subregional water table flow system that includes Yucca Mountain. Figure 2 shows the locations of cross-sections in the newly defined subregional flow system. Figure 3 shows a hypothesized east-west cross-section that extends from Ash Meadows to Furnace Creek Ranch in Death Valley. Under the new conceptual model, the mountain ranges serve as flow divides for the upper water table system. Some groundwater is hypothesized to flow from the Amargosa Desert and beneath the Funeral Mountains via the Paleozoic carbonate aquifer, finally contributing to spring discharge at Furnace Creek.

Given the importance of Czarnecki (1989) in presenting an alternate conceptual flow model, it is surprising that the subject study plan does not cite it. Another study plan (DOE, 1991) which supports this "synthesis" study does cite Czarnecki (1989) and includes a discussion about the alternate flow model.

Adequacy of Data to Support Regional Modeling

The study plan does not describe how the DOE will ensure that sufficient data will be obtained to adequately construct and calibrate subregional (or regional) groundwater models. It is not clear that data will be adequate to support planned 3-D modeling.

The subregional (or regional) flow system predicted by 2-D or 3-D numerical models will greatly depend on the completeness and representativeness of the boundary conditions. In most situations, mathematical boundary conditions can be inferred from the physical or hydraulic boundaries of the subregion. These mathematical boundary conditions, however, need to be reasonably confirmed by field data collection. In addition, sufficient data density along specified head boundaries is generally needed to properly reflect head gradients.

Three-dimensional (multilayer) numerical models can be useful tools for understanding the interactions between unconfined and confined aquifers. However, there must be sufficient hydrogeologic data to reasonably define and calibrate a model to justify the use of 3-D techniques. In other words, to reasonably model in three spatial dimensions, potentiometric and physical property data must be distributed in three dimensions.

The study plan (DOE, 1992) cites previous regional modeling reports and indicates that a preliminary quasi-3-D model has already been developed, citing Sinton and Downey (written communication). This model consists of two layers, the lower of which represents the Paleozoic carbonate rocks. On page 3.4-1 of the study plan, it is stated that "With the existing data base, use of more than two layers to represent the regional groundwater

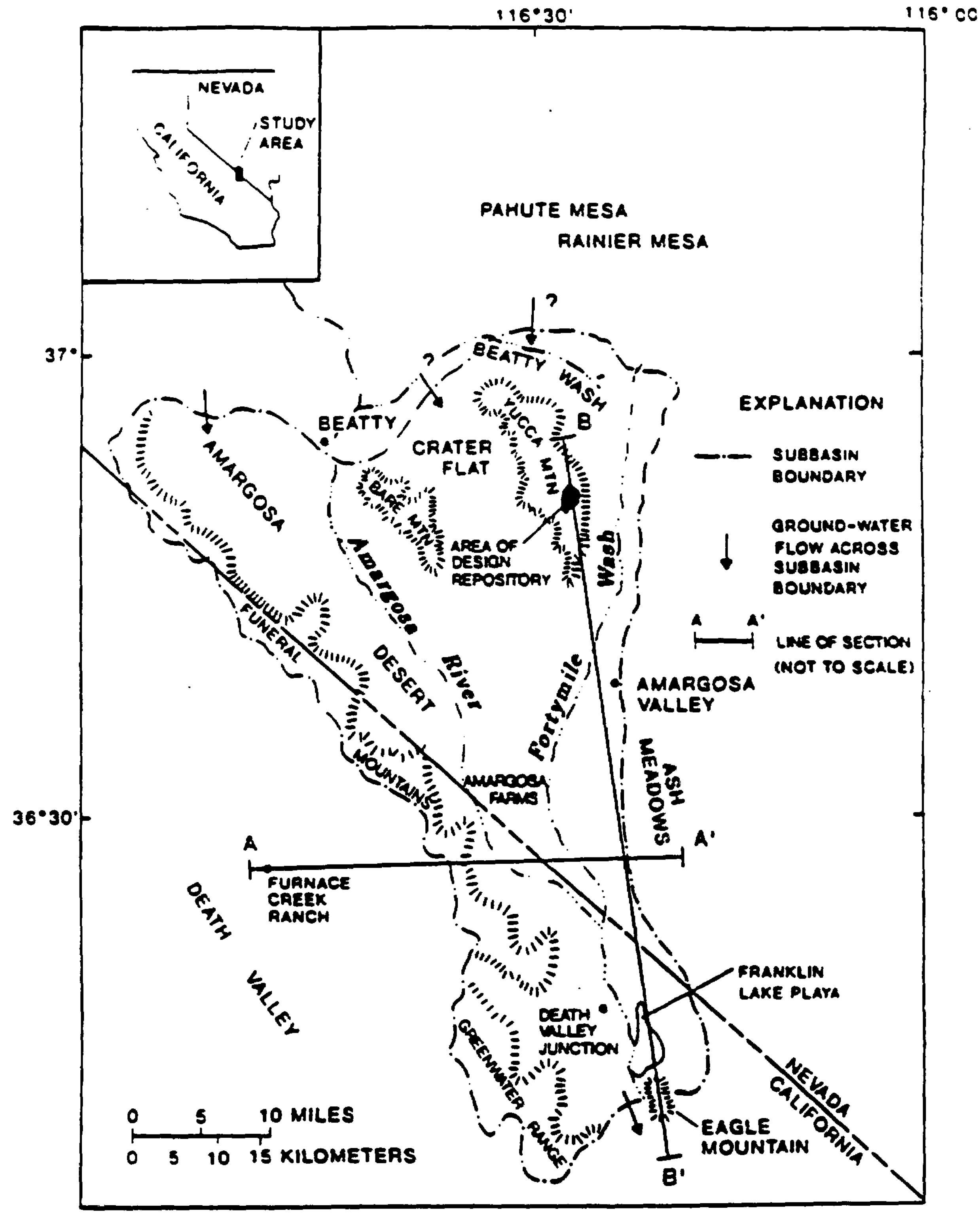

Figure 2. Location map of ground-water subbasin.
(DOE, 1991)

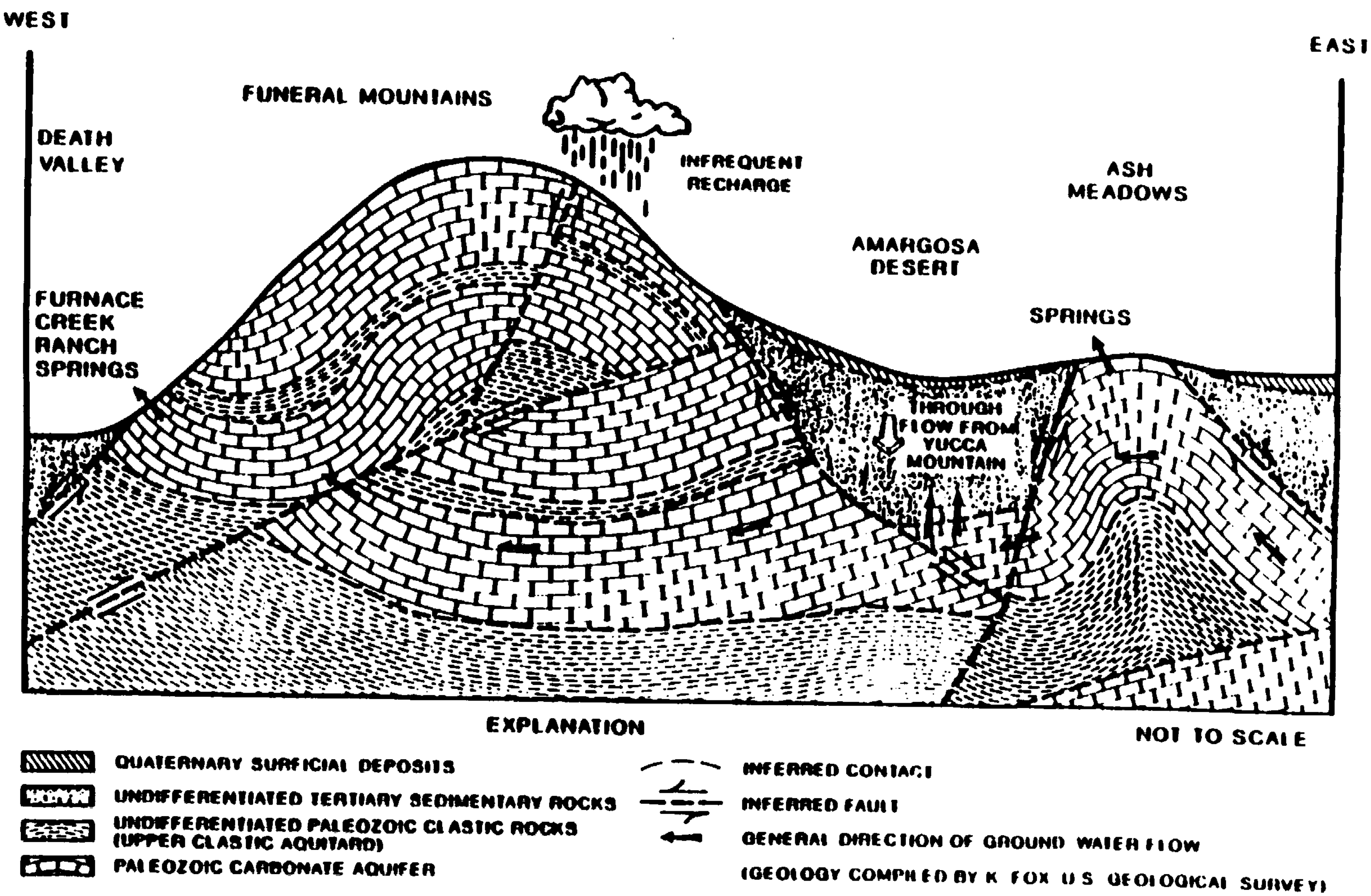

Figure 3. West-east diagrammatic cross section through subregional flow system (DOE, 1991)

flow system is not expected to be justified because of a sparsity of data on the three-dimensional hydrogeologic properties of the system."

It is not clear that 3-D modeling of even two layers can be supported given that very little hydrologic data presently exists for the deep carbonate aquifer system. In the vicinity of the Yucca Mountain Site, only one well (UE-25 p#1) penetrates deep Paleozoic carbonate rocks. At this location the carbonates are 1.2 km deep and have a hydraulic head that is about 19 m higher than in the overlying zone. Even within the tuffs that overlie the deep carbonate rocks, there are zones that are confined or semi-confined, illustrating the complexity of the saturated zone flow system. Unless a commitment is made to acquire the necessary data, there will not likely be enough potentiometric or physical property data from the Paleozoic carbonates to adequately calibrate a 3-D model.

Data limitations are also discussed in the study plan "Characterization of the Yucca Mountain Regional Ground Water Flow System" (DOE, 1991). That is the key study plan under which data will be collected to support the regional groundwater modeling activities. On page 3.1-6 of that plan, it is stated that: "Little is known about the distribution of hydraulic head with depth within the flow system. Hydraulic-head data in the vertical dimension are critical for calibrating three-dimensional models of ground-water flow. At present, only a handful of points exist where hydraulic head has been determined at various depths."

Additional wells to be drilled in the vicinity of Yucca Mountain may penetrate the Paleozoic aquifer and would contribute to 3-D <u>site</u> models. They would not, however, significantly add to <u>regional</u> well coverage. Wells proposed to be drilled in Crater Flat, near Lathrop Wells, and near the Funeral Mountains (DOE, 1991) would improve the regional data base, but it is questionable whether the data would be sufficient to help calibrate a 3-D model that includes the Paleozoic carbonates as a separate layer (see attached comment 3).

Regional Evaluation of Evapotranspiration (ET) and Recharge

It is not clear how estimates of ET and recharge will be obtained for use in regional models (see attached question 1). Study 8.3.1.2.1.3 concerns characterization of the regional groundwater flow system (DOE, 1991) and includes an activity titled "Evapotranspiration Studies." The objective of the activity is to estimate ET rates in the Amargosa Desert to provide data for regional and subregional models. Although the objective refers to the Amargosa Desert, the activity mainly emphasizes work at Franklin Lake Playa, a key discharge area. Franklin Lake Playa was identified in a previous modeling study (Czarnecki and Waddell, 1984) as having particular significance. In sensitivity studies of a parameter estimation model, specified flux at the Franklin Lake Playa had the largest effect of all the specified fluxes on the estimate of hydraulic properties in the vicinity of Yucca Mountain. As a result of the sensitivity studies, Czarnecki (1990) performed extensive fieldwork at the playa to measure hydraulic gradients and to evaluate various methods to estimate ET.

It is recognized that there is a need to obtain improved estimates of ET and groundwater underflow at Franklin Lake Playa, especially in light of the alternate conceptual flow model presented by Czarnecki (1989) in which the playa area may act as the principal discharge area for the subbasin that includes Yucca Mountain. There is also a need for improved estimates of ET for other areas within the region in order to better estimate rates of deep percolation through the vadose zone to the water table. Such estimates are dominated by ET rates because the percentage of precipitation that returns to the atmosphere via ET greatly exceeds the percentage of rainfall that ultimately becomes groundwater recharge.

Groundwater recharge rates are thought to be small over most of southern Nevada. More groundwater recharge is expected to occur in areas of higher elevation, due to lower temperatures and greater annual precipitation. Some areas, such as Forty-Mile Wash, are considered capable of producing high recharge fluxes during infrequent, surface-water runoff events of large magnitude. In his base-case, steady-state, subregional model, Czarnecki (1985) used areally distributed recharge rates ranging from 0.0 mm/yr (Amargosa Desert, western Rock Valley, Franklin Lake Playa, Funeral Mountains) to 410 mm/yr (Forty-Mile Wash). Intermediate recharge rates of 0.5 and 2.0 mm/yr were assigned to other areas, with Timber Mountain having a designated rate of 2.0 mm/yr.

In Czarnecki's (1985) base-case model, the total amount of areally distributed recharge was significant, being of the same magnitude as the total recharge across specified flow boundaries. Czarnecki (1985) modified the base-case model to simulate a future scenario of increased precipitation and recharge. He assumed a 100 % increase in precipitation which resulted in increased recharge rates. It was concluded that simulated groundwater fluxes near the repository area would be 2 to 4 times greater than for the base-case scenario. Given the very small recharge values that have been assumed for the base-case model, and the substantial changes in simulated flux that can result from small changes in recharge, it would be prudent to obtain an improved understanding of recharge and ET over the region.

Other studies related to evaluation of recharge and ET include 8.3.1.2.1.1 (meteorology for regional hydrology) and 8.3.1.2.2.1 (unsaturated zone infiltration). However, based on descriptions in the Site Characterization Plan (DOE, 1988), it is not apparent that they are intended to produce regional estimates of ET and discharge.

Application of Parameter Estimation Techniques

The study plan states that the regional and subregional models will be calibrated by adjusting hydraulic parameters. It is not clear whether this calibration will be performed manually or by use of an automated inverse modeling technique (Cooley, et al., 1986; Yeh, 1986) (see attached question 2).

SUMMARY

Except for open items related to this study plan, the subject study should provide the appropriate information needed for licensing. During the Phase I review (memo from Federline to Holonich, 3/16/92), the study plan was perceived to be related to SCA comments 6, 9, 10, and 95 (NRC, 1989). In consideration of the letter received from DOE on July 23rd, 1992 (from Roberts to Holonich), we have determined that these SCA comments comprise broader issues than can reasonably be addressed at the study plan level. Therefore, we consider that the attached three comments and two questions comprise the only open items directly related to this study plan (DOE, 1992).

RECOMMENDATIONS

Future reports that document groundwater modeling (whether on regional or site scales) should include adequate summaries of the wells and boreholes selected and used to calibrate models. The general criteria for selecting (or rejecting) boreholes as calibration wells should also be described. Types of supporting information that should be reported for calibration wells and boreholes include: (1) owner, and location coordinates of borehole; (2) borehole elevation and reference points (top of casing, etc.); (3) measured or reported water level elevation and date of measurement; (4) documented changes in water levels over time; (5) borehole construction data; (6) present or past use of borehole; (7) current condition of borehole; (8) aquifer identification; (9) available hydrochemical data, and other available information of hydrologic significance.

With respect to regional hydrogeologic data, the DOE should apply the guidance contained in NUREG-1298, "Qualification of Existing Data for High-Level Nuclear Waste Repositories" (NRC, 1988).

Also, the DOE contractor that will be performing the work has requirements with respect to the qualification of existing data. The U.S. Geological Survey has such requirements spelled out in Appendix G of its Quality Assurance Program Plan (YMP-USGS-QAPP). Basically, these requirements are designed to ensure that the level of confidence in the existing data will be commensurate with the intended use of the data.

The next revision of this study plan should include an updated list of references related to regional modeling, including Czarnecki (1989). The study plan should also include a discussion of the process for determining when and if major revisions are needed for existing models. Finally, the DOE should aggressively continue the search for existing sources of potentiometric and hydraulic property data in key areas such as the Funeral Mountains. Given the data collected in the Greenwater Range, the DOE's characterization of the subregional groundwater system should confirm whether these mountain ranges do indeed contain water table divides. If existing sources of data cannot be located, it would be necessary to drill new boreholes to confirm whether major modifications to existing models are needed.

The next revision of this study plan should include a detailed description of DOE's approach to ensure that the mathematical boundary conditions and other characteristics of 2-D and 3-D models are reasonably supported by field data. In particular, the DOE should assess the amount of data that will be needed to reasonably calibrate a 3-D model of regional groundwater flow. A determination should be made as to whether sufficient data exist or will become available to support 3-D modeling, particularly for the Paleozoic carbonate aquifer.

The DOE should identify those studies and activities that will provide regional estimates of recharge and evapotranspiration for use in regional groundwater modeling.

The DOE should identify and describe the specific approaches to be used in the model calibration process. Also, areas within the regional model where hydrologic testing data have been collected should be delineated. This should be made a part of the documentation for regional modeling and would clearly show those areas represented by actual data and those over which estimates must be obtained.

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CORRESPONDENCE

Memorandum from M. Federline (NRC/NMSS) to J. Holonich (NRC/NMSS) re: Phase I review of study "Hydrologic System Synthesis and Modeling," March 16, 1992.

Letter from J. P. Roberts (DOE, OCRWM) to J. J. Holonich (NRC, NMSS) re: open items related to study "Hydrologic System Synthesis and Modeling," July 23, 1992.

STUDY PLAN 8.3.1.2.1.4, REV. 0: REGIONAL HYDROLOGIC SYNTHESIS AND MODELING

Comment 1

The study plan does not address the selection and documentation of well data that will be used to calibrate regional models.

Basis

Previous reports on regional modeling in the Yucca Mountain region do not provide sufficient information about wells and boreholes used to obtain hydraulic heads (and other data) for model calibration. For example, Czarnecki and Waddell (1984) provide (in their Table 5) Nevada state coordinates (northing and easting) for nodes in their model grid that are nearest to well locations. But it would be better to have coordinates for the wells instead of the model nodes. Hydraulic heads are provided, along with data sources. However, of the five data sources listed, only two are published reports, and only one of these (Walker and Eakin, 1963) lists tabular information about wells in the region. Walker and Eakin (1963) is an acceptable reference, but it is almost 30 years old, and the well locations are given in township and range coordinates rather than the currently-used Nevada State plane coordinate system. This reference includes data from springs and more than 140 wells in the Amargosa Desert. It includes two wells in the vicinity of Yucca Mountain (Crater Flat) but does not include data from the Nevada Test Site. Waddell (1982) cited Thordarson and Robinson's (1971) inventory of over 6000 wells and springs within a 100-mile radius of the Nevada Test Site, a reference that is more than 20 years old.

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Recommendations

Future reports that document groundwater modeling (whether on regional or site scales) should include adequate summaries of the wells and boreholes selected and used to calibrate models. The general criteria for selecting (or rejecting) boreholes as calibration wells should also be described. Types of supporting information that should be reported for calibration wells and boreholes include: (1) owner, and location coordinates of borehole; (2) borehole elevations and reference points (top of casing, etc.); (3) measured or reported water level elevation and date of measurement; (4) documented changes in water level over time; (5) borehole construction data; (6) present or past use of borehole; (7) current condition of borehole; (8) aquifer identification; (9) available hydrochemical data, and other available information of hydrologic significance.

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STUDY PLAN 8.3.1.2.1.4, REV. 0: REGIONAL HYDROLOGIC SYNTHESIS AND MODELING

Comment 2

The study plan needs to be updated with respect to available literature on alternate conceptual models for the regional groundwater system. The study plan does not adequately describe the approach for modifying existing conceptual models based on new hydrogeologic data.

Basis

During the 1980s, the USGS performed a considerable amount of regional modeling for the area of southern Nevada. This work was documented in published reports, papers, and abstracts, including Waddell (1982), Czarnecki and Waddell (1984), and Czarnecki (1985). These documents are cited in the subject study plan. However, the study plan does not cite a key reference (Czarnecki, 1989) that presents potentiometric data from the Greenwater Range and a new conceptual model of groundwater flow. Czarnecki (1989) presents a new (or alternate) conceptual model of subregional groundwater flow. This new conceptualization is based on the acquisition of potentiometric data in the Greenwater Range, showing the probable presence of a groundwater flow divide beneath this range. Overall, the potentiometric data suggest the need for model recalibration and revision of the model boundaries of Czarnecki and Waddell (1984) and Czarnecki (1985). In Czarnecki's 1985 model, Franklin Lake Playa and Furnace Creek Ranch serve as discharge areas for the water table aquifer. On the basis of data from the Greenwater Range, Franklin Lake Playa may serve as the principal discharge area for the subregional water table flow system that includes Yucca Mountain. Under the new conceptual model, the mountain ranges serve as flow divides for the upper water table system. Some groundwater flows from the Amargosa Desert under the Funeral Mountains via the Paleozoic carbonate aquifer, finally contributing to spring discharge at Furnace Creek Ranch.

Given the importance of Czarnecki (1989) in presenting an alternate conceptual flow model, it is surprising that the subject study plan does not cite it. However, another study plan (DOE, 1991) which supports this "synthesis" study does cite Czarnecki (1989) and includes a discussion about the alternate flow model.

Recommendations

The next revision of this study plan should include an updated list of references related to regional modeling, including Czarnecki (1989). The study plan should also include a discussion of the process for determining when and if major revisions are needed for existing models. Finally, the DOE should aggressively continue the search for existing sources of potentiometric and hydraulic property data in key areas such as the Funeral Mountains. Given the data collected in the Greenwater Range, the DOE's characterization of the subregional groundwater system should confirm whether these mountain ranges do indeed contain water table divides. If existing sources of data cannot be located, it would be necessary to drill new boreholes to confirm whether major modifications to existing models are needed.

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STUDY PLAN 8.3.1.2.1.4, REV. 0: REGIONAL HYDROLOGIC SYNTHESIS AND MODELING

Comment 3

The study plan does not describe how the DOE will ensure that sufficient data will be obtained to adequately construct and calibrate subregional (or regional) groundwater models. It is not clear that data will be adequate to support planned 3-D modeling.

Basis

The study plan does not adequately describe how the DOE will ensure that sufficient data on boundary conditions, hyrogeologic properties, and hydraulic heads will be obtained for the regional and subregional models.

The subregional (or regional) flow system predicted by 2-D or 3-D numerical models will greatly depend on the completeness and representativeness of the boundary conditions. In most situations, mathematical boundary conditions can be inferred from the physical or hydraulic boundaries of the subregion. These mathematical boundary conditions, however, need to be reasonably confirmed by field data collection. In addition, sufficient data density along specified head boundaries is generally needed to properly reflect head gradients.

Three-dimensional (multilayer) numerical models can be useful tools for understanding the interactions between unconfined and confined aquifers. However, there must be sufficient hydrogeologic data to reasonably define and calibrate a model to justify the use of 3-D techniques. In other words, to reasonably model in three spatial dimensions, potentiometric and physical property data must be distributed in three dimensions.

The study plan (DOE, 1992) cites previous regional modeling reports and indicates that a preliminary quasi-3-D model has already been developed, citing Sinton and Downey (written communication). This model consists of two layers, the lower of which represents the Paleozoic carbonate rocks. On page 3.4-1 of the study plan, it is stated that "With the existing data base, use of more than two layers to represent the regional ground-water flow system is not expected to be justified because of a sparsity of data on the three-dimensional hydrogeologic properties of the system."

It is not clear that 3-D modeling of even two layers can be supported given that very little hydrologic data presently exists for the deep carbonate aquifer system. In the vicinity of the Yucca Mountain Site, only one well (UE-25 p#1) penetrates deep Paleozoic carbonate rocks. At this location the carbonates are

1.2 km deep and have a hydraulic head that is about 19 m higher than in the overlying zone. Even within the tuffs that overlie the deep carbonate rocks, there are zones that are confined or semi-confined, illustrating the complexity of the saturated zone flow system. Unless a commitment is made to acquire the necessary data, there will not likely be enough potentiometric or physical property data from the Paleozoic carbonates to adequately calibrate a 3-D model.

Data limitations are also discussed in the study plan "Characterization of the Yucca Mountain Regional Ground Water Flow System" (DOE, 1991). That is the key study plan under which data will be collected to support the regional groundwater modeling activities. On page 3.1-6 of that plan, it is stated that: "Little is known about the distribution of hydraulic head with depth within the flow system. Hydraulic-head data in the vertical dimension are critical for calibrating three-dimensional models of ground-water flow. At present, only a handful of points exist where hydraulic head has been determined at various depths."

Additional wells to be drilled in the vicinity of Yucca Mountain may penetrate the Paleozoic aquifer and would contribute to 3-D site models. They would not, however, significantly add to regional well coverage. Wells proposed to be drilled in Crater Flat, near Lathrop Wells, and near the Funeral Mountains (DOE, 1991) would improve the regional data base, but it is questionable whether the data would be sufficient to help calibrate a 3-D model that includes the Paleozoic carbonates as a separate layer.

Recommendations

The next revision of this study plan should include a detailed description of DOE's approach to ensure that the mathematical boundary conditions and other characteristics of 2-D and 3-D models are reasonably supported by field data.

In particular, the DOE should assess the amount of data that will be needed to reasonably calibrate a 3-D model of regional groundwater flow. A determination should be made as to whether sufficient data exist or will become available to support 3-D modeling, particularly for the Paleozoic carbonate aquifer.

References

DOE, 1991. Characterization of the Yucca Mountain Regional Ground Water Flow System: Study Plan 8.3.1.2.1.3, Rev. 0, by U.S. Geological Survey for U.S. Dept. of Energy, Office of Civilian Radioactive Waste Management, Washington, DC.

DOE, 1992. Regional Hydrologic Synthesis and Modeling: Study Plan 8.3.1.2.1.4, Rev. 0, by U.S. Geological Survey for U.S. Dept. of Energy, Office of Civilian Radioactive Waste Management, Washington, DC.

STUDY PLAN 8.3.1.2.1.4, REV. 0: REGIONAL HYDROLOGIC SYNTHESIS AND MODELING

Question 1

What approaches will be used to evaluate evapotranspiration (ET) and recharge on a regional basis? Under which studies and activities will this work be performed?

Basis

It is not clear how estimates of ET and recharge will be obtained for use in regional models. Study 8.3.1.2.1.3 concerns characterization of the regional groundwater flow system (DOE, 1991) and includes an activity titled "Evapotranspiration Studies." The objective of the activity is to estimate ET rates in the Amargosa Desert to provide data for regional and subregional models. Although the objective refers to the Amargosa Desert, the activity mainly emphasizes work at Franklin Lake Playa, a key discharge area. Franklin Lake Playa was identified in a previous modeling study (Czarnecki and Waddell, 1984) as having particular significance. In sensitivity studies of a parameter estimation model, specified flux at the Franklin Lake Playa had the largest effect of all the specified fluxes on the estimate of hydraulic properties in the vicinity of Yucca Mountain. As a result of the sensitivity studies, Czarnecki (1990) performed extensive fieldwork at the playa to measure hydraulic gradients and to evaluate various methods to estimate ET.

It is recognized that there is a need to obtain improved estimates of ET and groundwater underflow at Franklin Lake Playa, especially in light of the alternate conceptual flow model presented by Czarnecki (1989) in which the playa area may act as the principal discharge area for the subbasin that includes Yucca Mountain. There is also a need for improved estimates of ET for other areas within the region in order to better estimate rates of deep percolation through the vadose zone to the water table. Such estimates are dominated by ET rates because the percentage of precipitation that returns to the atmosphere via ET greatly exceeds the percentage of rainfall that ultimately becomes groundwater recharge.

Groundwater recharge rates are thought to be small over most of southern Nevada. More groundwater recharge is expected to occur in areas of higher elevation, due to lower temperatures and greater annual precipitation. Some areas, such as Forty-Mile Wash, are considered capable of producing high recharge fluxes during infrequent, surface-water runoff events of large magnitude. In his base-case, steady-state, subregional model, Czarnecki (1985) used areally distributed recharge rates ranging from 0.0 mm/yr (Amargosa Desert, western Rock Valley, Franklin

Lake Playa, Funeral Mountains) to 410 mm/yr (Forty-Mile Wash). Intermediate recharge rates of 0.5 and 2.0 mm/yr were assigned to other areas, with Timber Mountain having a designated rate of 2.0 mm/yr.

In Czarnecki's (1985) base-case model, the total amount of areally distributed recharge was significant, being of the same magnitude as the total recharge across specified flow boundaries. Czarnecki (1985) modified the base-case model to simulate a future scenario of increased precipitation and recharge. He assumed a 100 % increase in precipitation which resulted in increased recharge rates. It was concluded that simulated groundwater fluxes near the repository area would be 2 to 4 times greater than for the base-case scenario. Given the very small recharge values that have been assumed for the base-case model, and the substantial changes in simulated flux that can result from small changes in recharge, it would be prudent to obtain an improved understanding of recharge and ET over the region.

Other studies related to evaluation of recharge and ET include 8.3.1.2.1.1 (meteorology for regional hydrology) and 8.3.1.2.2.1 (unsaturated zone infiltration). However, based on descriptions in the Site Characterization Plan (DOE, 1988), it is not apparent that they are intended to produce regional estimates of ET and discharge.

Recommendation

The DOE should identify those studies and activities that will provide regional estimates of recharge and evapotranspiration for use in regional groundwater modeling.

References

Czarnecki, J. B., 1985. Simulated Effects of Increased Recharge on the Ground-Water Flow System of Yucca Mountain and Vicinity, Nevada-California: Water-Resources Investigations Report 84-4344, U.S. Geological Survey, Denver, Colo., 33 p.

Czarnecki, J. B., 1989. Characterization of the Subregional Groundwater Flow System at Yucca Mountain and Vicinity, Nevada-California: Radioactive Waste Management and the Nuclear Fuel Cycle, Vol. 13 (1-4), p. 51-61.

Czarnecki, J. B., 1990. Geohydrology and Evapotranspiration at Franklin Lake Playa, Inyo County, California: Open-File Report 90-356, U.S. Geological Survey, Denver, Colo., 96 p.

Czarnecki, J. B. and R. K. Waddell, 1984. Finite-Element Simulation of Ground-Water Flow in the Vicinity of Yucca Mountain, Nevada-California: Water-Resources Investigations Report 84-4349, U.S. Geological Survey, Denver, Colo., 38 p.

DOE (U.S. Dept. of Energy), 1988. Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada: 7 Volumes, DOE/RW-0160, Office of Civilian Radioactive Waste Management, Washington, DC.

DOE, 1991. Characterization of the Yucca Mountain Regional Ground Water Flow System: Study Plan 8.3.1.2.1.3, Rev. 0, by U.S. Geological Survey for U.S. Dept. of Energy, Office of Civilian Radioactive Waste Management, Washington, DC.

STUDY PLAN 8.3.1.2.1.4, REV. 0: REGIONAL HYDROLOGIC SYNTHESIS AND MODELING

Question 2

Will the calibration of the regional and subregional flow models be performed by use of an automated parameter estimation technique (i.e., inverse method)? If so, what techniques and codes will be used for the parameter estimation?

Basis

The study plan states that the regional and subregional models will be calibrated by adjusting hydraulic parameters. It is not clear whether this calibration will be performed manually or by use of an automated inverse modeling technique (Cooley, et al., 1986; Yeh, 1986).

Recommendation

The DOE should identify and describe the specific approaches to be used in the model calibration process. Also, areas within the regional model where hydrologic testing data have been collected should be delineated. This should be made a part of the documentation for regional modeling and would clearly show those areas represented by actual data and those over which estimates must be obtained.

References

Cooley, R. L., L. F. Konikow, and R. L. Naff, 1986. Non-linear-regression Groundwater Flow Modeling of a Deep Regional Aquifer System: Water Resources Research, 22(13), p. 1759-1778.

Yeh, W. W-G, 1986. Review of Parameter Identification Procedures in Groundwater Hydrology; The Inverse Problem: Water Resources Research, 22(2), p. 95-108.

Except for open items related to this study plan, the subject study should provide the appropriate information needed for licensing. During the Phase I review (memo from Federline to Holonich, March 16, 1992), the study plan was perceived to be related to SCA comments 6, 9, 10, and 95. In consideration of the letter received from DOE on July 23rd, 1992 (from Roberts to Holonich), we have determined that these SCA comments comprise broader issues than can reasonably be addressed at the study plan level. Therefore, we consider that the attached three comments and two questions comprise the only open items directly related to this study plan.

This review was performed by Neil Coleman of the Hydrologic Transport Section who may be contacted at 504-2530. The Phase II comments were reviewed by CNWRA staff who also contributed to the review.

/S/

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