University of California Davis McClellan Nuclear Research Center

Reactor Environmental Report

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1.0 Purpose/Methodology

1.1 Purpose of and Need for Action

The University of California Davis McClellan Nuclear Research Center (MNRC) houses an open tank, light-water, graphite moderated 1.0 MW (previously 2 MW) steady state TRIGA reactor made by General Atomics. This is the most common type of research reactor in the world. The MNRC reactor is one of only a few dozen operating research and test reactors in the United States. The reactor was originally built in the late 1980s by the US Air Force making it one of the newest research reactors in the country. Unlike the majority of other TRIGA reactors the MNRC reactor was purpose built to perform neutron radiography on airplane structures. This mission continued on even after the McClellan Air Force base was close when the facility was transferred to UC Davis.

The MNRC provides irradiation services for various researchers at universities world-wide, US national laboratories, and US private industry. Irradiation services include seed mutagenesis studies, geochronology irradiations, and radiation hardness test for electronics. The most significant use of the facility is arguably performing neutron radiography on energetic devices used for Department of Defense applications and the space industry. MNRC is currently one of two facilities in the country that provide this service and it is unlikely this number will increase. The loss of MNRC would represent a huge loss to this vital multibillion dollar a year industry.

MNRC also provide educational experiences for UC Davis students as well as other students at regional universities (e.g. Sacramento State University, UC Berkeley, etc.). Lastly the facility operates a large area outreach program for high schools and middle school to expose young students to the nuclear sciences.

The purpose and need for the renewal of the operating license of MNRC is to provide an option that allows the facility to continue to engage in research, educational, and outreach programs as well as to support the United States' energetic device industry. Due to importance of work performed at the MNRC, the University of California Davis is submitting a request for license renewal for a term of 20 years. This will permit operation until August 18th 2038.

1.2 Approach to Conducting the Environmental Reviews

NUREG-1537, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Nuclear Reactors" (Reference [1]), identifies that license renewal of research reactors is an action that requires an environmental assessment. The staff of MNRC has prepared this Environmental Report (ER) to support the NRC's review of the environmental regulations pertinent to MNRC's license renewal request.

Regulatory guidance for the preparation of ERs for research reactors is minimal. However, the guidance originating from the renewal of operating licenses for commercial nuclear power plants is both significant and comprehensive. To provide a thorough and comprehensive ER, MNRC has used this guidance to identify and evaluate issues related to license renewal of a research reactor. This same methodology was used successfully by the Missouri University Research Reactor (MURR).

This ER has been prepared in accordance with Supplement 1 to Regulatory Guide 4.2, "Preparation of Supplemental Environmental Reports for Applications to Renew Nuclear Power Plant Operating Licenses" (Reference [2]) and its companion document, NUREG- 1555, Supplement 1, "Standard Review Plans for Environmental Reviews for Nuclear Power Plants" (Reference [3]). Information contained in NUREG-1437, "Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Plants" (Reference [4]) was reviewed for applicability to research reactors in general and MNRC in particular. While the use of Supplement 1 to Regulatory Guide 4.2 and NUREG-1555 is not required, these documents provided guidance for comparison purposes only and to ensure a thorough review of any potential environmental issues that could be affected by the continued operation of the MNRC Research Reactor.

In the GEIS, the NRC presented the results of their review of the 92 issues that have the potential to be impacted by license renewal of nuclear power plants. As a result of this review, each of the 92 issues was placed into one of two categories. Category 1 issues (69) are those issues for which the NRC has determined that:

- Environmental impacts associated with the issue have been determined to apply to either all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristics.

- A single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts (except for collective off-site radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal).

- Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

Category 2 issues (21) are those issues for which the potential environmental significance must be determined on a plant specific basis. The remaining two issues, chronic effects of exposure to electromagnetic fields and environmental justice were not categorized. The results of the NRC review are summarized in Table 9.1 of NUREG- 1437 (Reference [4]) and have been codified in 10 CFR 51, Appendix B to Subpart A (Reference [5]).

The conclusions presented in the GEIS with respect to the review of the 92 issues are applicable to the license renewal of commercial nuclear power reactors and are not necessarily applicable to the license renewal of research reactors. Therefore, each of the 92 issues listed in 10 CFR 51 was evaluated to determine if there was any potential impact due to the license renewal of MNRC. No credit was taken in this review for any of the conclusions drawn by the NRC in the GEIS. However, the reviews performed by the NRC to reach their conclusions were used.

To ensure a consistent format, the results of the review of the 92 issues described in 10 CFR 51 are discussed as outlined in Supplement 1 to Regulatory Guide 4.2, "Preparation of Supplemental Environmental Reports for Applications to Renew Nuclear Power Plant Operating Licenses" (Reference [2]). Section 4.1 contains the results of the review of the 21 Category 2 issues and the 2 issues not categorized in NUREG-1437. Section 4.2 contains the results of the review of the 69 Category 1 issues. The Category 1 issues are grouped by area of potential impact similar to the groupings used in Appendix B to 10 CFR 51.

Because most of the Category 1 issues are not applicable to continued operation of MNRC, grouping the issues reduces the verbiage and facilitates review of the document.

In all cases, sufficient information is provided for those issues that are applicable to continued operation of MNRC to support the finding of no significant environmental impact. Where an issue has been determined not to be applicable, sufficient information to support that determination is provided in this ER. The results of the review for all 92 issues are summarized in Table 1. In addition to providing a summary of the conclusions regarding each issue, this table provides a reference/guide to the section within the ER where each of the issues applicable to license renewal of MNRC is discussed. The Category 2 issues, which are identified in Table 1, are discussed in Section 4.1.

The remaining items that are applicable to the license renewal of MNRC, which are identified next to the headings in Table 1 are discussed in Section 4.2.

MNRC's evaluation of each of the 92 issues has determined that a specific issue is either: 1) not applicable to continued operation, 2) has no significant potential to impact the environment, or 3) has no significant impact on the environment. A detailed discussion of the results of the environmental review is provided in Section 4.1 and 4.2.

In addition to the 92 issues, MNRC has reviewed the information in the facility's Safety Analysis Report (SAR) for any new or significant information that might represent an adverse impact on the environment. In addition, the latest information related to population, land use, and other socioeconomic factors were reviewed to determine if any of this information represents an adverse environmental impact related to the continued operation of MNRC. Based on this review, MNRC has determined that there is no new or significant information related to potential environmental impacts resulting from operation of MNRC for the period of the license renewal term.

Table 1 provides a summary of the results of the evaluation of all 92 issues related to potential environmental impact of license renewal for nuclear power plants. These 92 issues are listed in 10 CFR 51, Table B-1 in Appendix B to Subpart A.

Table 1 Surface Water Qualify, Hydrology, and Use

Issue	GEIS	Summary of Results
Impact on surface water quality	1	N/A. The facility does not discharge water to a body of surface water. No major refurbishment is planned.
Impacts on surface water use	1	N/A The facility does not use surface water. No major refurbishment is planned.
Altered current patterns at intake or discharge structure	1	N/A The facility does not have an intake or discharge structure.
Altered salinity gradients	1	N/A The facility does not discharge water to a body of surface water.
Altered thermal stratification of lakes	1	N/A The facility does not discharge water to a body of surface water.
Temperature effects on sediment transport capacity	1	N/A The facility does not discharge water to a body of surface water.
Scouring due to discharge of cooling water	1	N/A The facility does not discharge water to a body of surface water.
Eutrophication	1	N/A The facility does not discharge water to a body of surface water. There is no impact on aquatic life.
Discharge of Chlorine or other biocides	1	N/A The facility does not discharge cooling water containing chlorine, corrosion inhibitors, or other biocides to a body of surface water.
Discharge of sanitary wastes or minor chemical spills	1	N/A Sanitary waste is discharged to a sewage treatment facility. The mitigation of chemical spills is addressed by the facility's adherence to the UC Davis chemical hygiene program and the use of a spill retention tank.
Discharge of metals in waste water	1	N/A The facility uses a cooling tower and does not directly discharge water to a body of surface water. All discharges are to the sanitary sewer system.
Water use conflicts (plants with a once-through cooling system)	1	N/A The facility does not have a once-through cooling system.

Water use conflicts (plants w/cooling towers and makeup from small body of water)	2	The facility does not obtain makeup from any body of surface water. Water use is minimal compared to availability. (See section 4.1.1)

Aquatic Ecology

Issue	GEIS	Summary of Results
Refurbishment	1	N/A The facility does not discharge water to a body of water. No major refurbishment activities are currently planned.
Accumulation of contaminants in sediment	1	N/A The facility does not discharge water to a body of surface water. There is no impact on aquatic ecology.
Entrainment of phytoplankton and zooplankton	1	N/A The facility does not discharge water to a body of surface water. There is no impact on aquatic ecology.
Cold Shock	1	N/A The facility does not discharge water to a body of surface water. There is no impact on aquatic ecology.
Thermal plume barrier to migrating fish	1	N/A The facility does not discharge water to a body of surface water. There is no impact on aquatic ecology.
Distribution of aquatic organisms	1	N/A The facility does not discharge water to a body of surface water. There is no impact on aquatic ecology.
Premature emergence of aquatic insects	1	N/A The facility does not discharge water to a body of surface water. There is no impact on aquatic ecology.
Gas supersaturation (gas bubble disease)	1	N/A the facility does not discharge gasses to a body of surface water. There is no impact on Aquatic ecology.
Low dissolved oxygen in the discharge	1	N/A The facility does not discharge water to a body of surface water. There is no impact on aquatic ecology.
Losses among organisms exposed to sub-lethal doses	1	N/A The facility does not discharge water to a body of surface water. There is no impact on aquatic ecology.

Stimulation of nuisance organisms	1	N/A The facility does not discharge water to a body of surface water. There is no impact on aquatic ecology.

Aquatic Ecology (Once-through and cooling pond heat dissipation system)

Issue	GEIS	Summary of Results
Entrainment of fish and shellfish in early life stages (refurbishment activities)	2	N/A The facility does not use a once-through cooling system; nor does it use a cooling pond. (See section 4.1.2)
Impingement of fish and shellfish (refurbishment activities)	2	N/A The facility does not use a once-through cooling system; nor does it use a cooling pond. (See section 4.1.3)
Heat shock (refurbishment activities	2	N/A The facility does not use a once-through cooling system; nor does it use a cooling pond. (See section 4.1.4)
Entrainment of fish and shellfish in early stages of life	1	N/A The facility does not use a once-through cooling system; nor does it use a cooling pond.
Heat shock	1	N/A The facility does not use a once-through cooling system; nor does it use a cooling pond.

Groundwater Use and Quality

Issue	GEIS	Summary of Results
Groundwater use and quality	1	The quantity of groundwater used by the facility is very small compared to that used by the surrounding area (McClellan Business Park).
Groundwater use conflicts (plant use <100 gpm)	1	N/A Facility uses <100 gpm. Water is obtained from an extensive aquafer and reservoir system in the Sierra Nevada mountains.
Groundwater use conflicts (plant use >100 gpm)	2	N/A Facility uses <100 gpm during normal operation.
Ground water use conflicts (cooling tower w/ makeup from small stream)	2	N/A Cooling tower make-up water is not obtained from small stream (See section 4.1.6).
Groundwater use conflicts (Plants with Ranney Wells)	2	N/A The facility does not use Ranney Wells.

Groundwater quality degradation (plants with Ranney Wells)	1	N/A The facility does not use Ranney Wells
Groundwater quality degradation (saltwater intrusion)	1	N/A The facility is not located near a body of saltwater. Saltwater is not used at the facility.
Groundwater quality degradation (cooling ponds in saltwater marshes)	1	N/A The facility is not located near a salt marsh
Groundwater quality degradation (cooling ponds at inland sites)	2	N/A The facility does not have a cooling pond. (See section 4.1.8)

Terrestrial Resources

Issue	GEIS	Summary of Results
Refurbishment impacts	2	The facility is not planning any refurbishment during the license renewal term.
Cooling tower impacts on crops and ornamental vegetation	1	Given the location and small size of the cooling tower, its operation has no impact on crops or ornamental vegetation in the area.
Cooling tower impacts on native plants	1	Given the location and small size of the cooling tower, its operation has negligible impact on native vegetation in the area.
Bird collisions with cooling towers	1	N/A The cooling tower is relatively small and does not have a strong updraft. Bird collisions are extremely rare.
Cooling pond impacts on terrestrial resources	1	N/A the facility does not have a cooling pond.
Power line right-of-way management	1	N/A the facility does not produce electricity. There are no power transmission lines.
Bird collisions with power lines	1	N/A The facility does not produce electricity. There are no power transmission lines.
Impacts of electromagnetic fields on flora and fauna	1	N/A The facility does not produce electricity. There are no power transmission lines.
Floodplains and wetlands on power line right-of-ways	1	N/A The facility does not produce electricity. There are no power transmission lines.

Threatened or Endangered Species

Issue	GEIS	Summary of Results
Threatened or endangered species	2	Refer to Section 4.1.10

Air Quality

Issue	GEIS	Summary of Results
Air quality during refurbishment activities	2	No major refurbishment activates are planned during the license renewal term. (See section 4.1.11)
Air quality effects of transmission lines	1	N/A The facility does not produce electricity. There are no power transmission lines.

Land Use

Issue	GEIS	Summary of Results
Onsite land use	1	No additional use of land is expected during the license renewal term.
Power line right-of-way	1	N/A The facility does not produce electricity. There are no power transmission lines.

Human Health

Issue	GEIS	Summary of Results
Public radiation exposure during refurbishment	1	N/A No major refurbishment activities are planned to support license renewal or during the license renewal term.
Occupational radiation exposure-refurbishment	1	N/A No major refurbishment activities are planned to support license renewal or during the license renewal term.
Microbiological organisms (occupational health)	1	Not a concern due to facility operations and occupational health practices implemented at the facility.

Microbiological organism (public health)	2	See Section 4.1.12.
Noise	1	N/A The facility is small and produces very little noise that is audible at the facility fence line.
Electromagnetic fields, acute effects	2	N/A The facility does not generate electricity or electromagnetic fields (See section 4.1.13).
Electromagnetic fields, chronic effects	No Category	N/A The facility does not generate electricity or electromagnetic fields (See Section 4.1.13).
Public radiation exposure (license renewal term)	1	Radiations dose to the general public is small and will remain small for the duration of the license renewal
Occupational radiation exposure (license renewal)	1	Occupational radiation doses are very small. They are expected to remain very small during the duration of the license renewal.

Socioeconomics

Issue	GEIS	Summary of Results
Housing impacts	2	See Section 4.1.14.
Public services, safety, social services, tourism & recreation	1	This is a small research reactor located on a light industry business park. It does not affect public services, tourism, or recreation.
Public services, public utilities	2	The water and electricity use at the facility are negligible and has minimal impact on the public services or public utilities.
Public services, education (refurbishment activities)	2	N/A No significant refurbishments are planned during the license renewal term. (See section 4.1.17)
Public services, education (license renewal term)	1	The facility is a research reactor that has a positive impact on education.
Offsite land use (refurbishment)	2	N/A No significant refurbishments are planned during the license renewal term. (See section 4.1.17)
Offsite land use (license renewal term)	2	No significant population or tax revenue changes are expected during the license renewal term. (See section 4.1.17)

Public services (transportation)	2	No significant numbers of people are, or will be, employed at the site (See section 4.1.18).
Historic and archaeological resources	2	No refurbishment activities are planned during the license renewal term (See Section 4.1.19).
Aesthetic impacts (refurbishment)	1	N/A No major refurbishment activities are planned during the license renewal term.
Aesthetic impacts (license renewal term)	1	Due to the small size of the facility and its location on a light industrial park, there is no aesthetic impact.
Aesthetic impacts (transmission lines)	1	N/A The facility does not generate electricity and has no transmission lines.

Postulated Accidents

Issue	GEIS	Summary of Results
Design basis accidents	1	Due to the reactor's intrinsically safe design, the consequences of a design basis accident have negligible environmental impact.
Severe accidents	2	The facility has analyzed the Maximum Hypothetical Accident and the results show that no adverse environmental impact would result (see section 4.1.20).

Uranium Fuel Cycle and Waste Management

Issue	GEIS	Summary of Results
Offsite radiological impacts-individual, not due to fuel or high-level waste disposal	1	Refer to section 4.2.11 for a summary of the results of the environmental review.
Offsite radiological impacts-collective, not from fuel or high-level waste.	1	Refer to section 4.2.11 for a summary of the results of the environmental review.
Offsite radiological impacts-fuel and high-level waste	1	Refer to section 4.2.11 for a summary of the results of the environmental review.
Non-radiological impacts of uranium fuel cycle	1	Refer to section 4.2.11 for a summary of the results of the environmental review.
Low-level waste storage and disposal	1	Refer to section 4.2.11 for a summary of the results of the environmental review.

Mixed waste storage and disposal	1	Refer to section 4.2.11 for a summary of the results of the environmental review.
On-site spent fuel	1	N/A The facility does not permanently store spent fuel on-site. Spent fuel will not be permanently stored on-site during the license renewal term.
Non-radiological waste	1	Refer to section 4.2.11 for a summary of the results of the environmental review.
Transportation	2	See section 4.1.21

Decommissioning

Issue	GEIS	Summary of Results
Radiation doses	1	Doses to the public have been shown to be significantly below established limits during facility operation. Occupational doses have also been shown to be historically well below limits. Public and occupation doses are not expected to increase significantly during the license renewal term.
Waste management	1	Operating the facility for the term of the license renewal would not produce significant amounts of additional solid waste to be disposed of during decommissioning. Solid waste is routinely shipped off-site for disposal.
Air quality	1	Operating the facility has no impact on air quality now or during the license renewal term.
Water quality	1	N/A Operation of the facility has no adverse impact on water quality now or during the license renewal term.
Ecological resources	1	N/A Operation of the facility has no ecological impact now or during the license renewal term.
Socioeconomic impacts	1	Operation of the facility has minimal socioeconomic impacts now or during the license renewal term.

Environmental Justice

Issue	GEIS	Summary of Results
Environmental justice	No Category	See Section 4.1.22

2.0 Site and Environmental Interfaces

2.1 Site Description

The UCD/MNRC reactor is located a few miles northeast of downtown Sacramento, California on the former site of McClellan AFB. Sacramento lies in the Central Valley between the coast range and the Sierra Nevada, about 90 miles northeast of San Francisco, California (Figure 1). The adjacent lands are located in the Great Valley subdivision of the Pacific Border Physiographic Province (Reference [6]). The area is situated on the alluvial plains of the Sacramento River and its tributaries (Reference [7]). The land is relatively flat, ranging in elevation from 50-75 ft (15-23 m) above mean sea level. Soil cover of about 4 ft (1.2 m) consists of sandy loam (Reference [8]). The surface soil is moderately permeable but the subsoil has low permeability. The soils have moderate water-holding capacity and pose a slight erosion hazard.

The UCD/MNRC reactor is located approximately eight miles northeast of downtown Sacramento, California in the city of North Highlands (Figure 2). The reactor and the city of North Highlands are in Sacramento County, California located northwest of the intersection of Watt Avenue, Roseville Road, and I-80 and is between the communities of North Highlands- Foothills Farms, Arden-Arcade, and Rio Linda-Elverta.

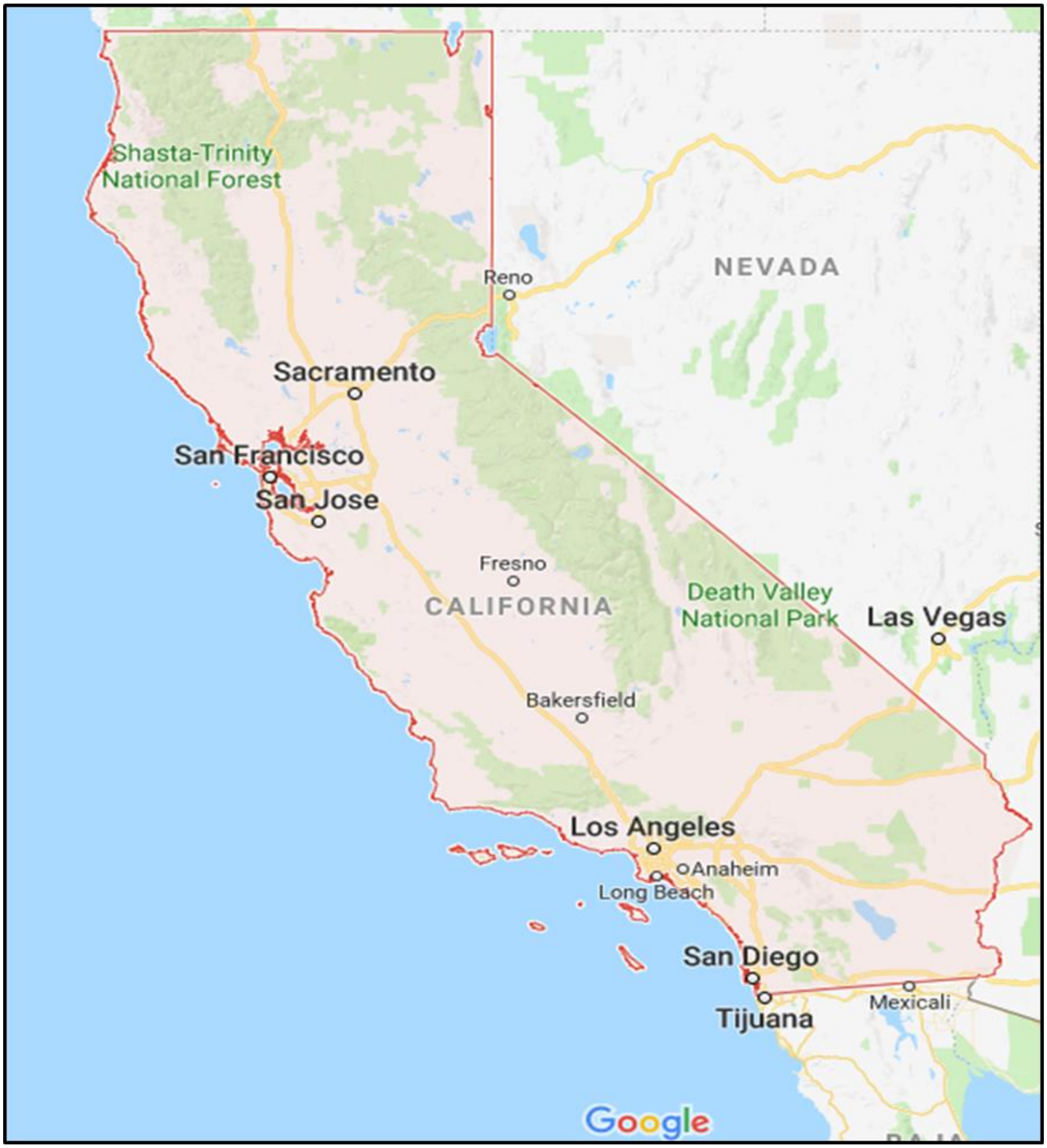

Figure 1 Map of the State of California

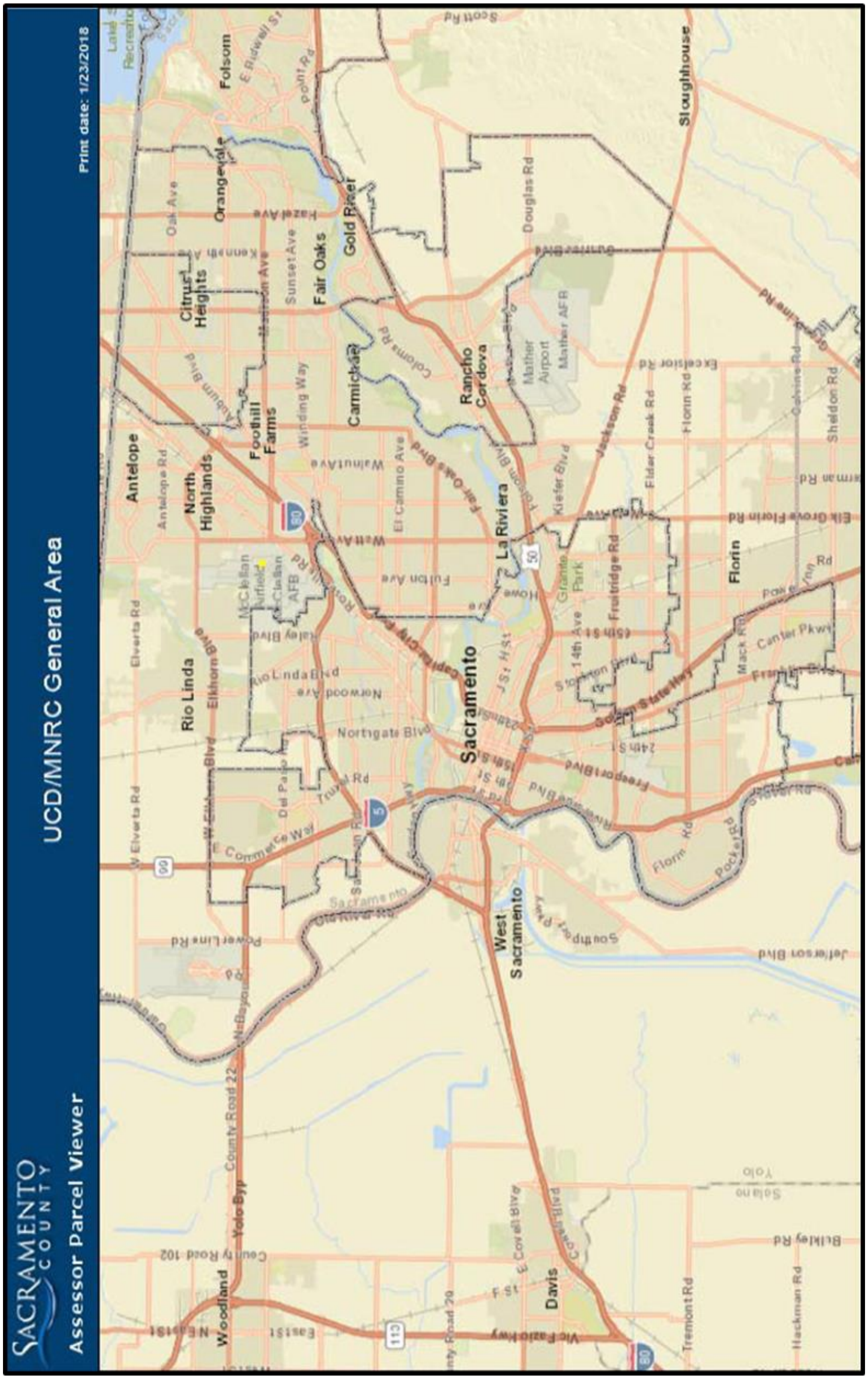

Figure 2 Map of Greater Sacramento Area

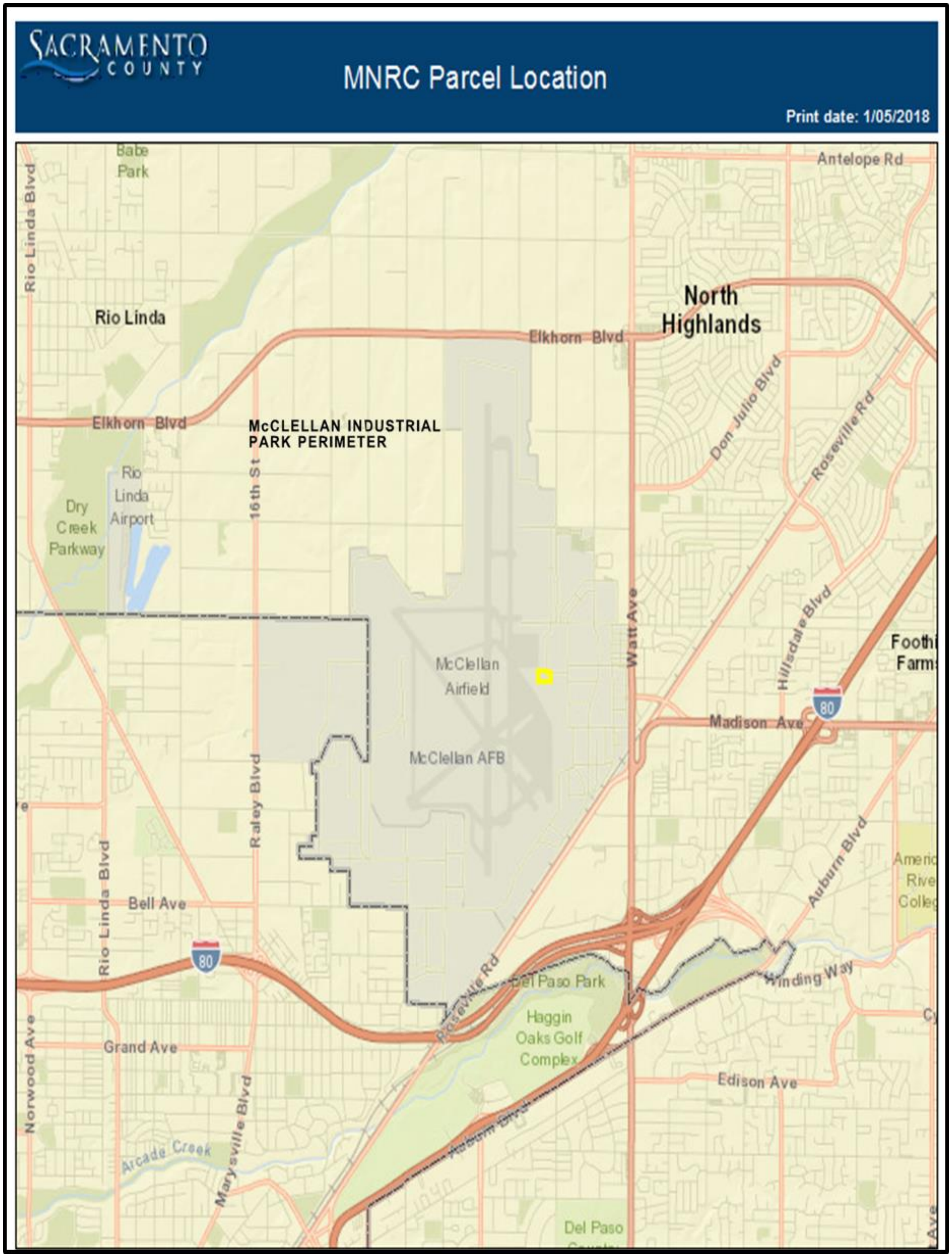

Figure 3 Map of the Area Surround the McClellan Business Park (former McClellan AFB)

2.2 Physiography

2.2.1 Hydrologic Description

The former Air Force Base and adjacent lands are located in the Great Valley subdivision of the Pacific Border Physiographic Province (Reference [6]). They are situated on the alluvial plains of the Sacramento River and its tributaries (Reference [7]). The land is relatively flat, ranging in elevation from 50-75 ft above mean sea level. Soil cover of about 4 ft consists of sandy loam (Reference [8]). The surface soil is moderately permeable but the subsoil has low permeability. The soils have moderate water-holding capacity and pose a slight erosion hazard.

The UCD/MNRC site is underlain by a thick (>1,000 ft) section of unconsolidated sediments deposited by streams draining the Sierra Nevada. The uppermost deposits are termed the Victor Formation which is approximately 50 to 100 ft thick at the UCD/MNRC site. The Victor Formation is composed of the heterogeneous shifting streams that drained the Sierra Nevada in Pleistocene time. These streams left sand and gravel in channel-like structures that grade laterally and vertically into silt and clay in a manner that provides little correlation of materials from area to area. This is characteristic of floodplain or low-sloping alluvial fan deposits.

Underlying the Victor Formation is a series of alluvial deposits, termed the Laguna or Fair Oaks Formations. These alluvial deposits are composed of a heterogeneous assemblage of beds of silt, clay, and sand with lenticles of gravel deposited on westward-sloping floodplains by meandering, sluggish streams. Some of the sands are clean and well sorted while some of the gravels are extremely silty and poorly sorted. Sediments of the Laguna Formations are variable; for example, in one area the formation consists of compact silt, clay with lenses of poorly sorted gravel, sand, and silt, and in others it contains sand with only a few interbeds of clay and silt.

Underlying the Victor, Laguna, and Fair Oaks Formations is a volcanic unit termed the Mehtren Formation. In the vicinity of the UCD/MNRC site, this formation is composed of sedimentary deposits derived from reworking of andesitic tuff-breccias which issued from volcanic vents in the Sierra Nevada. Typically, these are referred to as “black sands” in drillers logs. The black sands generally are fairly soft and well sorted. They are formed as fluvial deposits, having been derived from andesitic detritus washed down the slopes of the Sierra Nevada. Beds of black sand are commonly about 2 meters thick, although beds up to 6 meters or more have been reported. Where exposed in road cuts, these beds exhibit crossbedding, indicating a steam-laid mode of origin. Associated with the black sands are lenticular beds of stream gravel containing andesitic cobbles and boulders up to a meter or more in diameter. Also associated with the sands are beds of brown to blue clay and silt. In addition to these sedimentary units, volcanic mudflow units have apparently also been encountered. The Mehtren Formation is the major aquifer of the Sacramento area. The thickness of the Mehtren formation in the vicinity of the base is unknown, but probably exceeds 300 ft.

2.2.2 Floods

The natural surface drainage around the UCD/MNRC site has been altered by construction of a series of storm drains. The North Sacramento, Del Paso Heights, Robla, Rio Linda, and Elverta areas drain storm water runoff to the west through Arcade Creek, Magpie Creek, Rio Linda Creek, Dry Creek, and a series of shallow natural ditches and swales (Figure 4). Rather than emptying onto the flat farmland of the Natomas area, as they once did, these creeks and ditches are intercepted by the East Natomas Main Drainage Canal and carried via Bannon Slough to the Sacramento River. In the area, elevation above sea level ranges from about 90 ft in the northeast to 50 ft in the southwest. The extensively-wooded, double channel Dry Creek is the most important component of the natural drainage system serving the study area. Dry Creek begins to the east in Placer County where it collects from a large watershed in the Roseville vicinity.

Two rivers, the Sacramento and American, flow through the Sacramento area (Figure 5). The American River flows approximately five miles south of the UCD/MNRC site. There are two flood control dams on this river approximately 20 miles upstream. The major dam which forms Folsom Lake is an earthen structure. Directly downstream of Folsom Dam is Nimbus Dam. This is a concrete structure and forms Lake Natomas. The Sacramento River flows approximately five miles west of the UCD/MNRC site. This river handles the runoff from areas north of Sacramento.

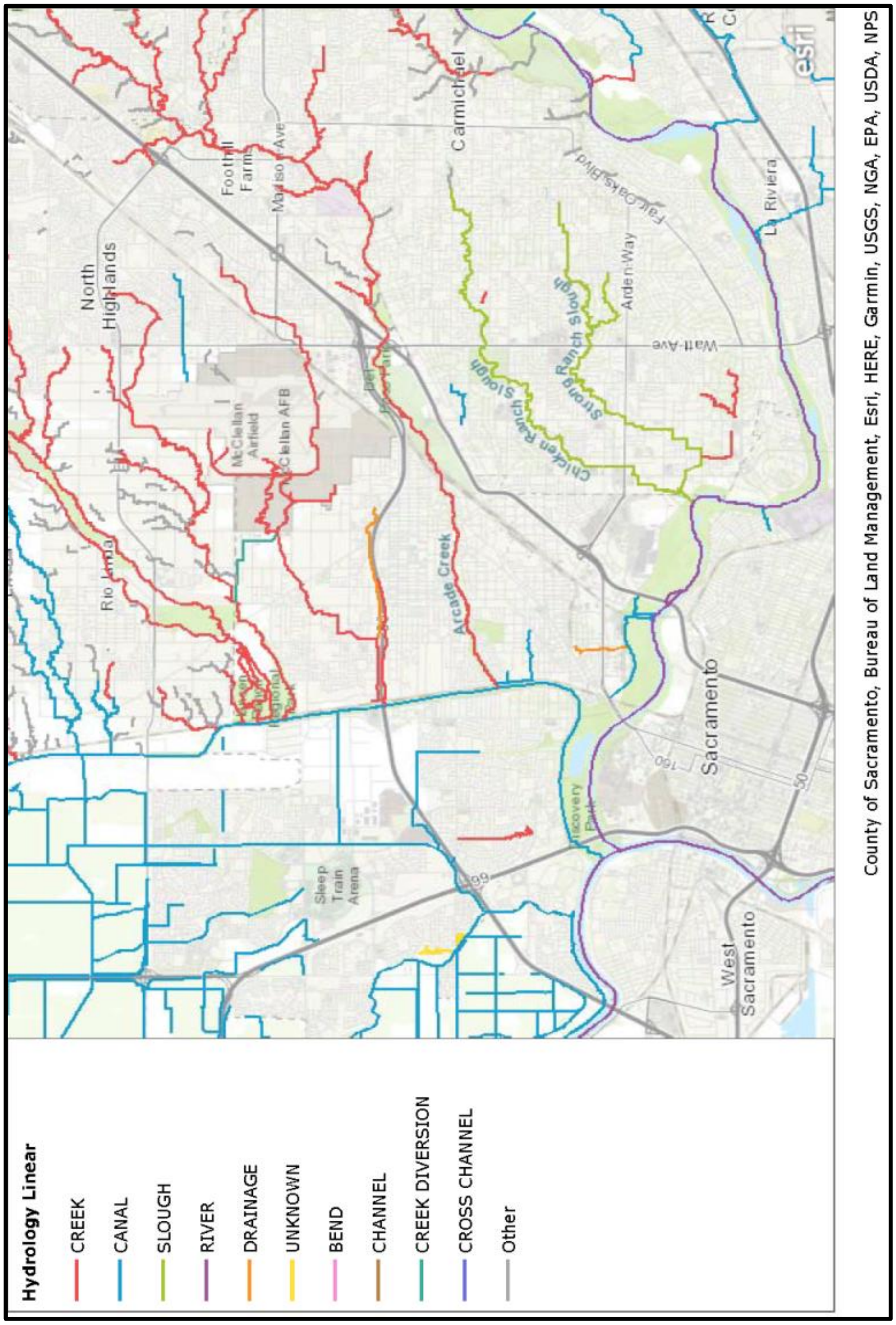

Figure 4 UCD/MNRC Local Hydrology

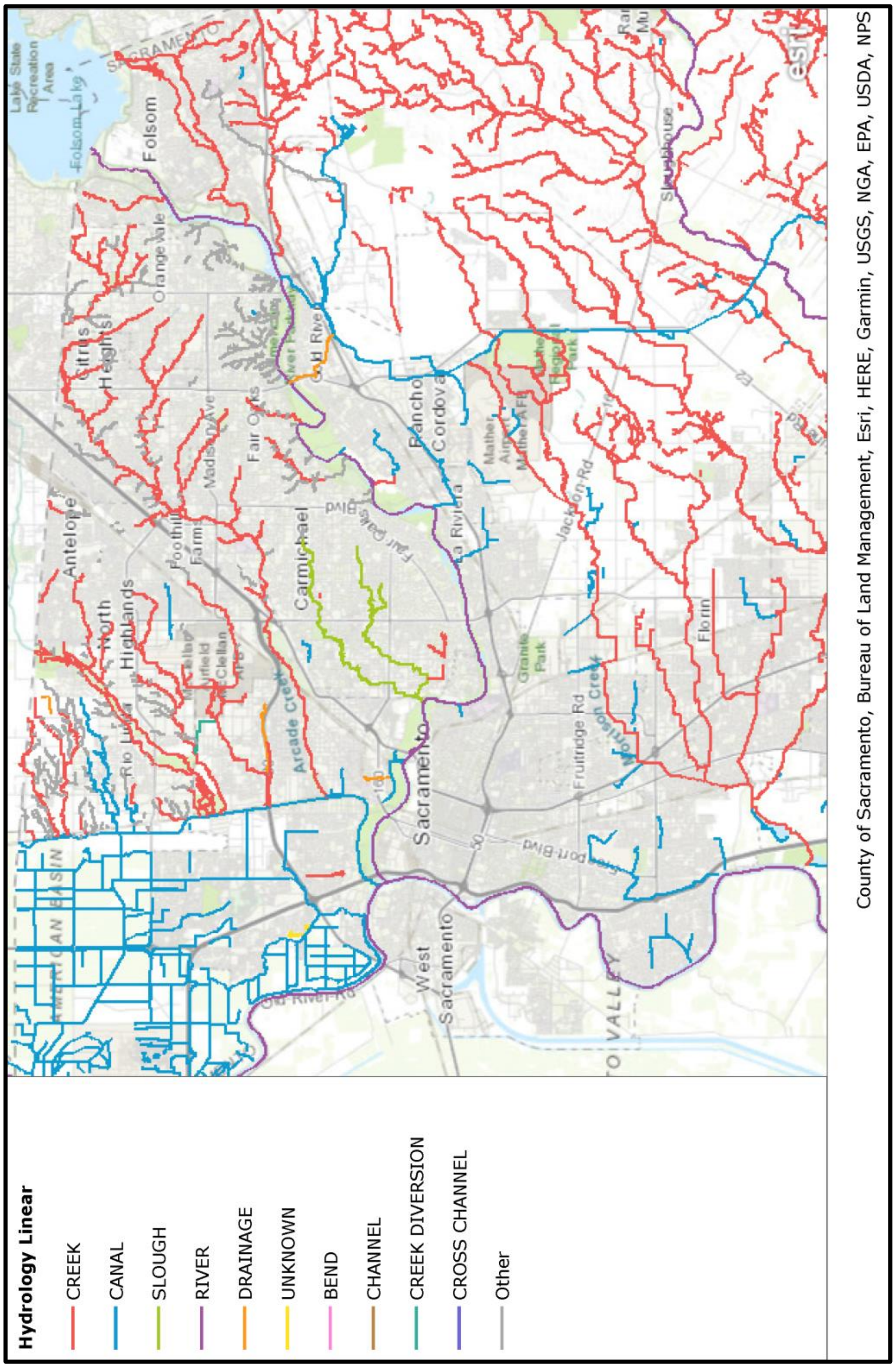

Figure 5 Sacramento County Hydrology

Neither of these rivers presents a flood hazard to the UCD/MNRC facility. The nearest 100 yr floodplain is about 3,400 ft (1,037 m) from the site of the UCD/MNRC (Figures 6-9).

2.2.3 Accidental Release of Liquid Effluents in Surface Waters

The probability of an accidental release of radioactive liquid effluents from the UCD/MNRC in surface waters is extremely low. Two UCD/MNRC systems may contain radioactive liquid: the reactor primary and the water purification systems. All of the components for these systems; reactor tank, pumps, heat exchangers, filters, resin tanks, valves, and piping, are located within the UCD/MNRC reactor and equipment rooms. Any contaminated water leakage from this equipment will be wiped up and disposed of as discussed in Chapter 11 of the SAR. The only other areas where contaminated water may be encountered is in the radiography bays and the men's washroom. The radiography bays are all interconnected so that any liquid in any bay will ultimately drain into the sump in Bay 1, which is the lowest point in the facility. Any leakage from the reactor tank would also ultimately end up in this sump. Any water collected in the sump is pumped into an above ground liquid storage tank. The decontamination shower located in the men's washroom also drains into the storage tank. Both the men's room decontamination shower and sink are posted as "for decontamination purposes only." There are no floor drains in the men's washroom that lead to the industrial waste. Any water entering the tank, even if other than the reactor systems, will be analyzed for radioactive materials. Any contaminated water in the Bay 1 sump would be conveyed to the above ground storage tank, which is not connected to the sanitary sewer. The retention tank itself is approximately 4,500 gallons in capacity as is the waterproof berm around the retention tank (combined capacity is ~9,000 gallons).

If radioactive liquid entered the retention, samples would be taken from the retention tank to verify the isotopes present. In order to dispose of radioactive liquid in the retention tank, the liquid would most likely be pumped into water tight drums, mixed with concrete, and disposed of as solid low-level waste. Liquid waste from the retention tank has never been processed into solid waste in the facility's history. The last discharges of liquid waste from the retention tank took place in 2002 (I-125) and prior to 2000 (tritium). In both cases the total activity of material discharged was less than 1.0 mCi, which is significantly less than the regulatory limit. The I-125 discharge was due to a failed I-125 production system and the tritium discharge was due to the 2.0 MW reactor upgrade. Both of these discharges were project specific and are not expected to occur again in the facility's lifetime.

2.2.4 Geology, Seismology, and Geotechnical Engineering

The Sacramento area is located in Seismic Zone 3 of the Uniform Building Code. In general, seismic activity is not as great in the area as it is in the coastal areas (References [9], [10], [11] and [12]). Based on a review of historical records, the maximum-intensity earthquake in Sacramento in historical times has been about VII on the Modified Mercalli scale (References [11]and [12]). This intensity was the result of earthquakes centered about 20 mi (32 km) west of Sacramento with an estimated magnitude of 6.0 to 6.5 on the Richter scale. Earthquakes of the intensity of VII are characterized by collapse of weak chimneys, moderate damage to masonry walls, fall of cornices from high buildings, and fall of some nonstructural, unreinforced brick walls (References [11]and [12]). However, earthquakes of higher intensity could have occurred prior to the coverage of the historical record, and higher intensity earthquakes are possible in the future Figure 10 (References [13], [14], and [15]) is a historical summary of the seismic activity in the area.

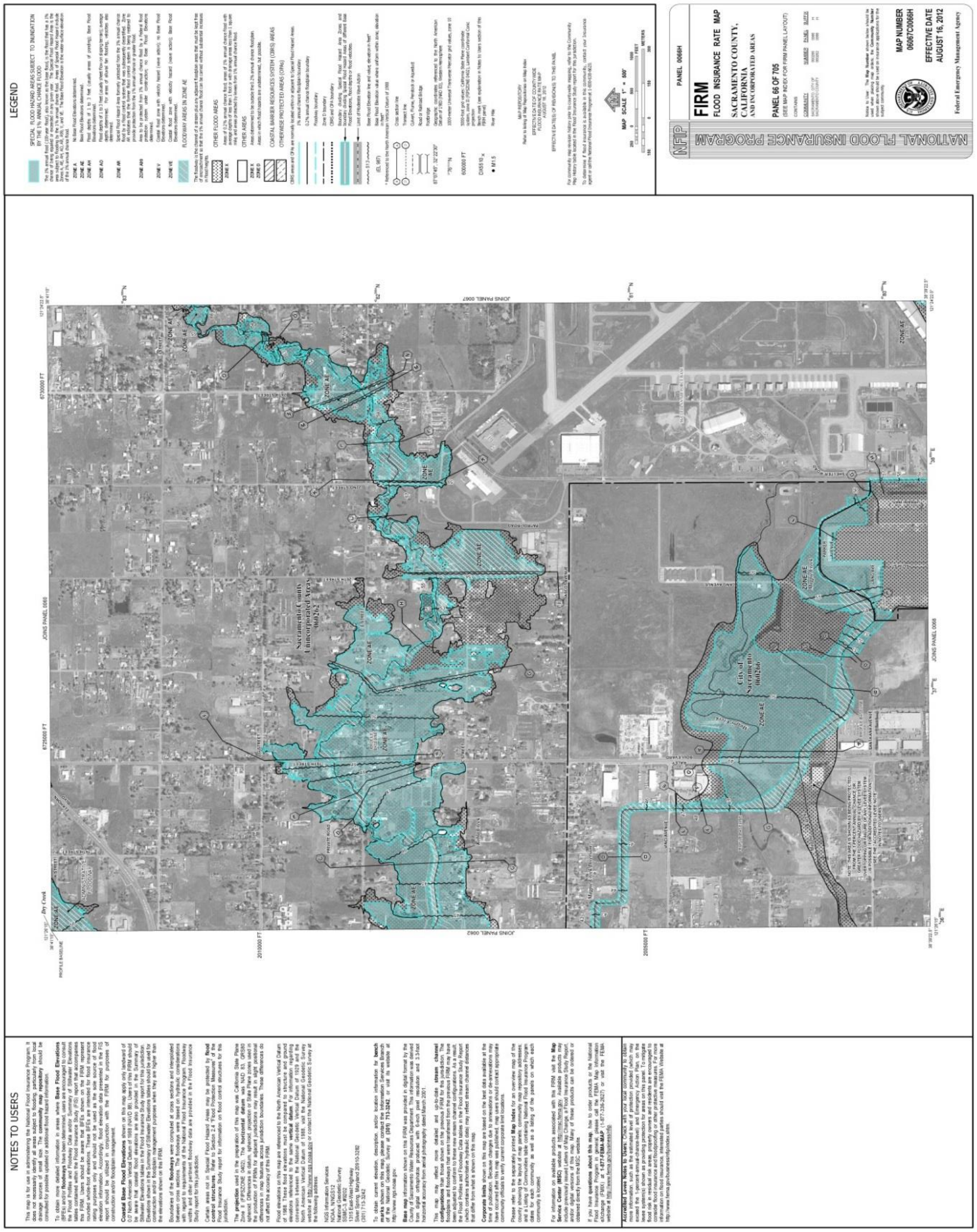

Figure 6 McClellan Business Park 100 Year Flood Plan Northwest Quadrant

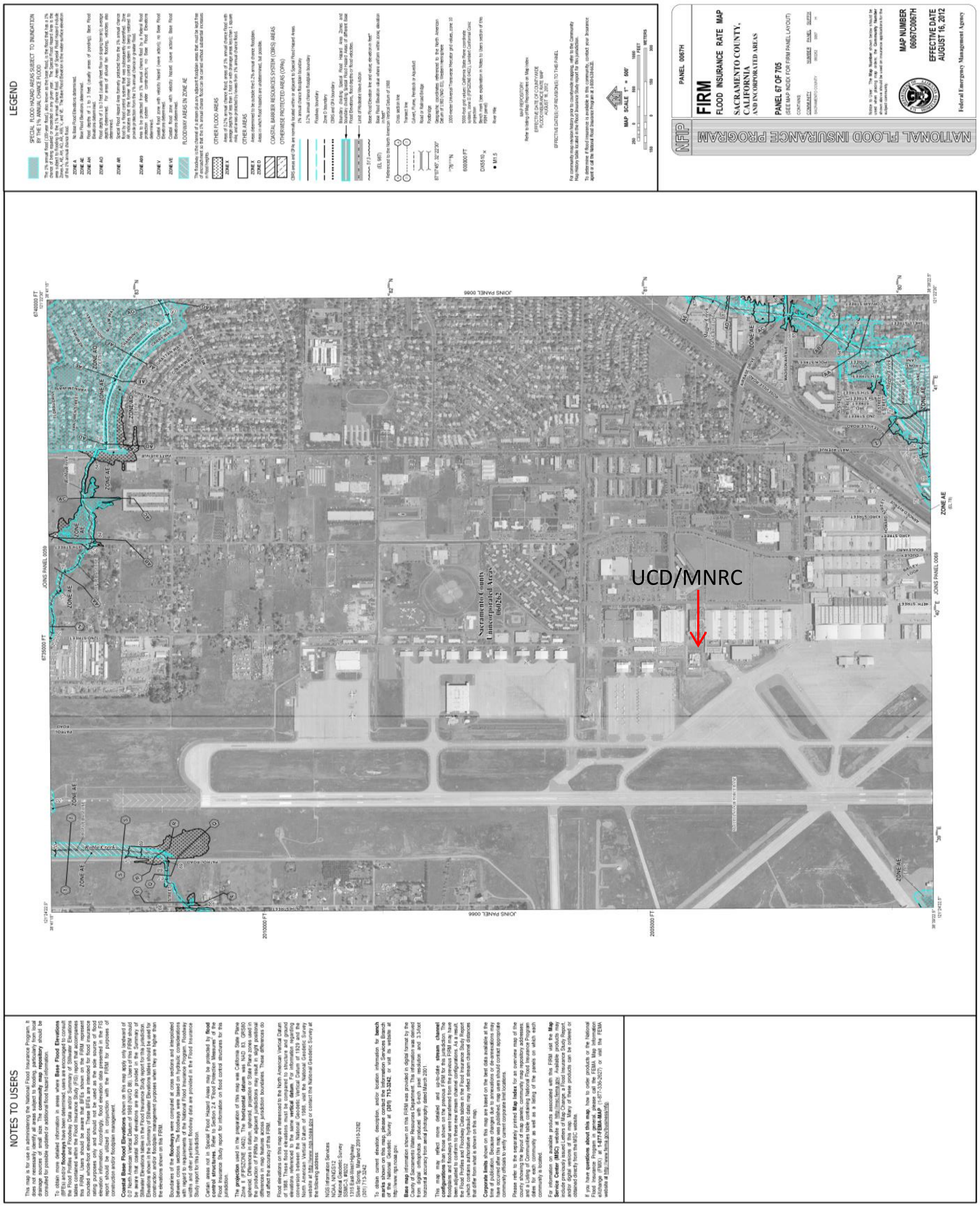

Figure 7 McClellan Business Park 100 Year Floodplain Northeast Quadrant

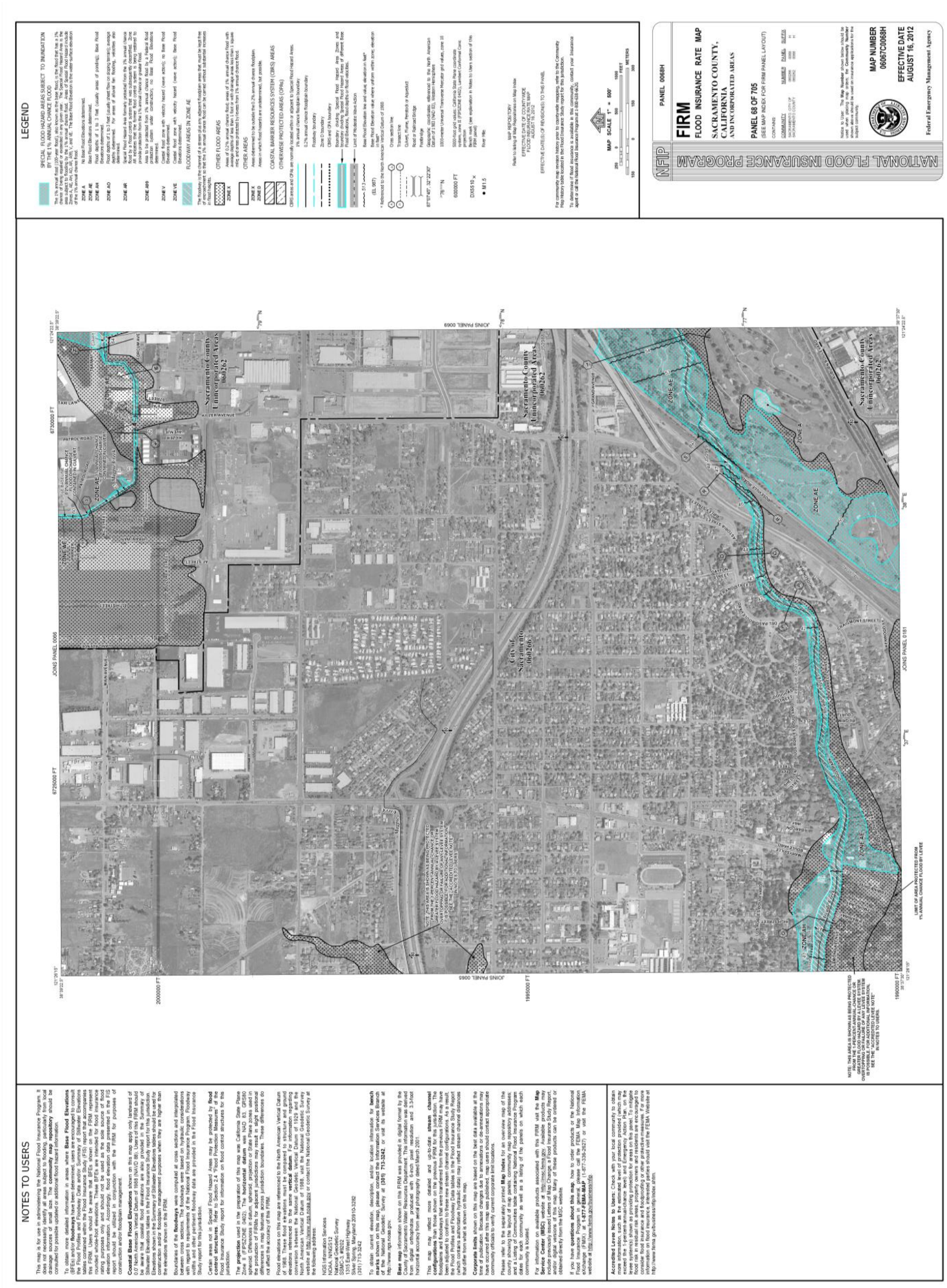

Figure 8 McClellan Business Park 100 Year Floodplain Southwest Quadrant

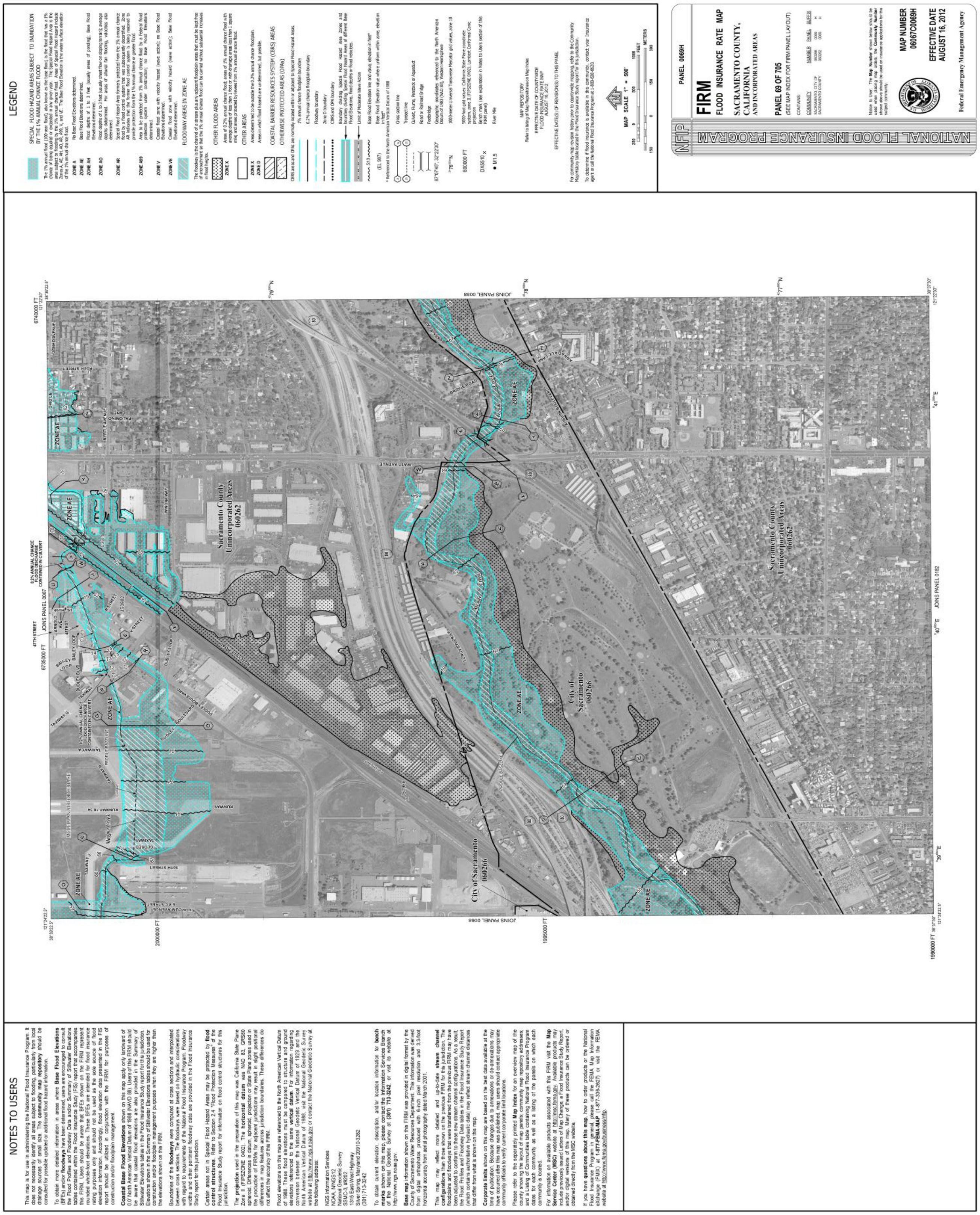

Figure 9 McClellan Business Park 100 Year Floodplain Southeast Quadrant

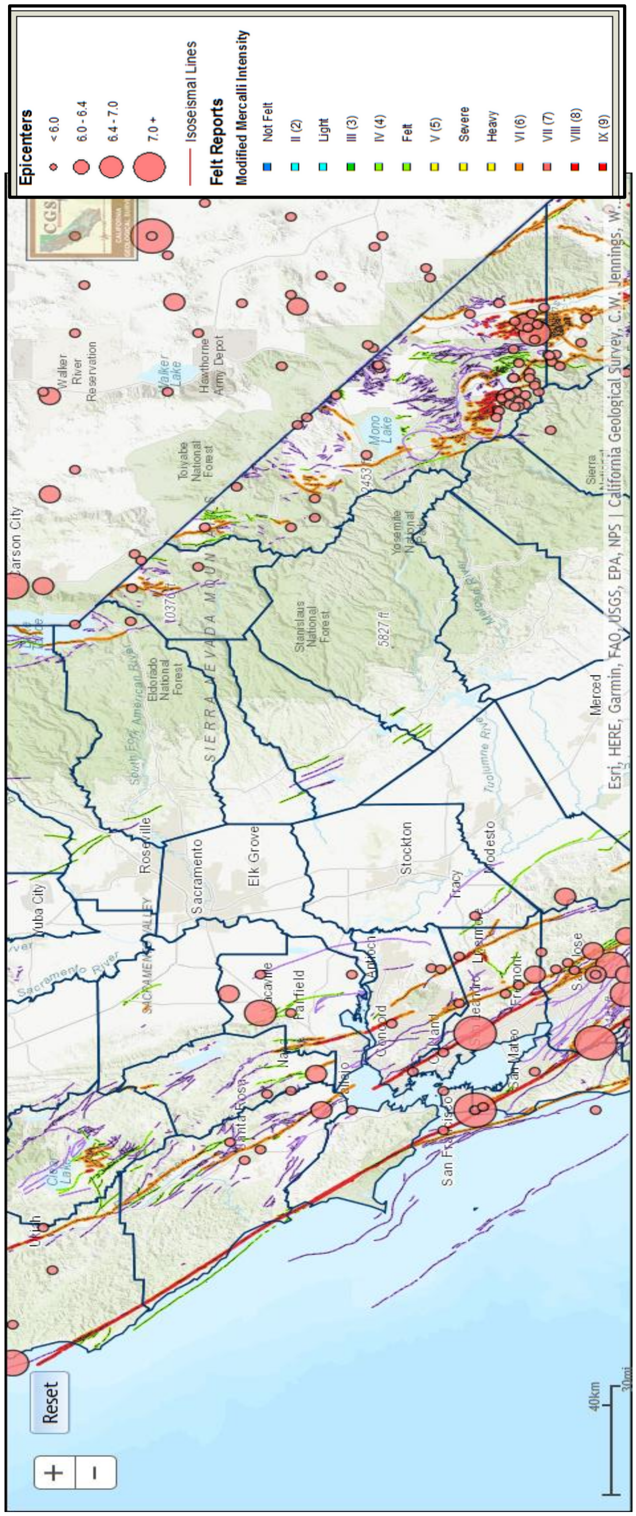

Figure 10 Earthquake Fault Epicenter Map of California (Partial)

California contains innumerable earthquake faults. Some of these faults are shown in Figure 11, including the known faults around Sacramento (Reference [16], [17]). It is quite probable that other surface and subsurface faults also exist; however, this can only be positively determined by adequate explorations. The fact that no surface faults appear on the map in the Sacramento or San Joaquin Valleys may only indicate that sediments laid down during late geologic time cover the fault scars. On the other hand, rock or the firmer sediments usually found in the hill and mountain areas retain the evidence of faults over long time periods.

As shown in the figure, surface faulting has been identified in the Bear Mountain fault zone some 25 miles east of Sacramento and in the Rumsey Hills area west of Woodland. A number of subsurface faults have been found during explorations for gas near Sacramento as reported by the Division of Oil and Gas of the California Department of Conservation. Such subsurface faulting is reported near Freeport and Clarksburg just to the south of Sacramento; in the Todhunter Lake area a few miles north and east of Davis; and in the Rio Vista area, to identify a few areas near Sacramento. Data are not available to indicate the existence of subsurface faulting nearer to or within the City of Sacramento.

Geologic investigations to date have not discovered evidence indicating movement on subsurface faults in the Sacramento Valley more recent than Eocene time, about 40 million years ago. Eocene rocks extend generally from the surface of the ground to 0.5 to 0.75 kilometer depth. One fault in the Folsom area, recently mapped by the California Division of Mines and Geology, has been interpreted as having moved during the Quaternary Period.

One conclusion based on this evidence is that except for the possibly more recent movement on the fault in the Folsom area, there has been no near surface fault displacement in, or within close proximity of Sacramento during the past 40 million years. The focal depth of California earthquakes (the depth below the surface of the earth to the start of the rupture in the rock that provides the energy for the quake) ranges from a few kilometers to 15 to 20 kilometers, and therefore earthquakes of a smaller magnitude could have originated here during the past 40 million years, but the faulting might not have extended into or through this layer of post-Eocene rocks.

A second conclusion is that faulting did extend to the surface, but the evidence for this surface breaking either has not yet been found or is undiscernible in the sediments which fill the valley.

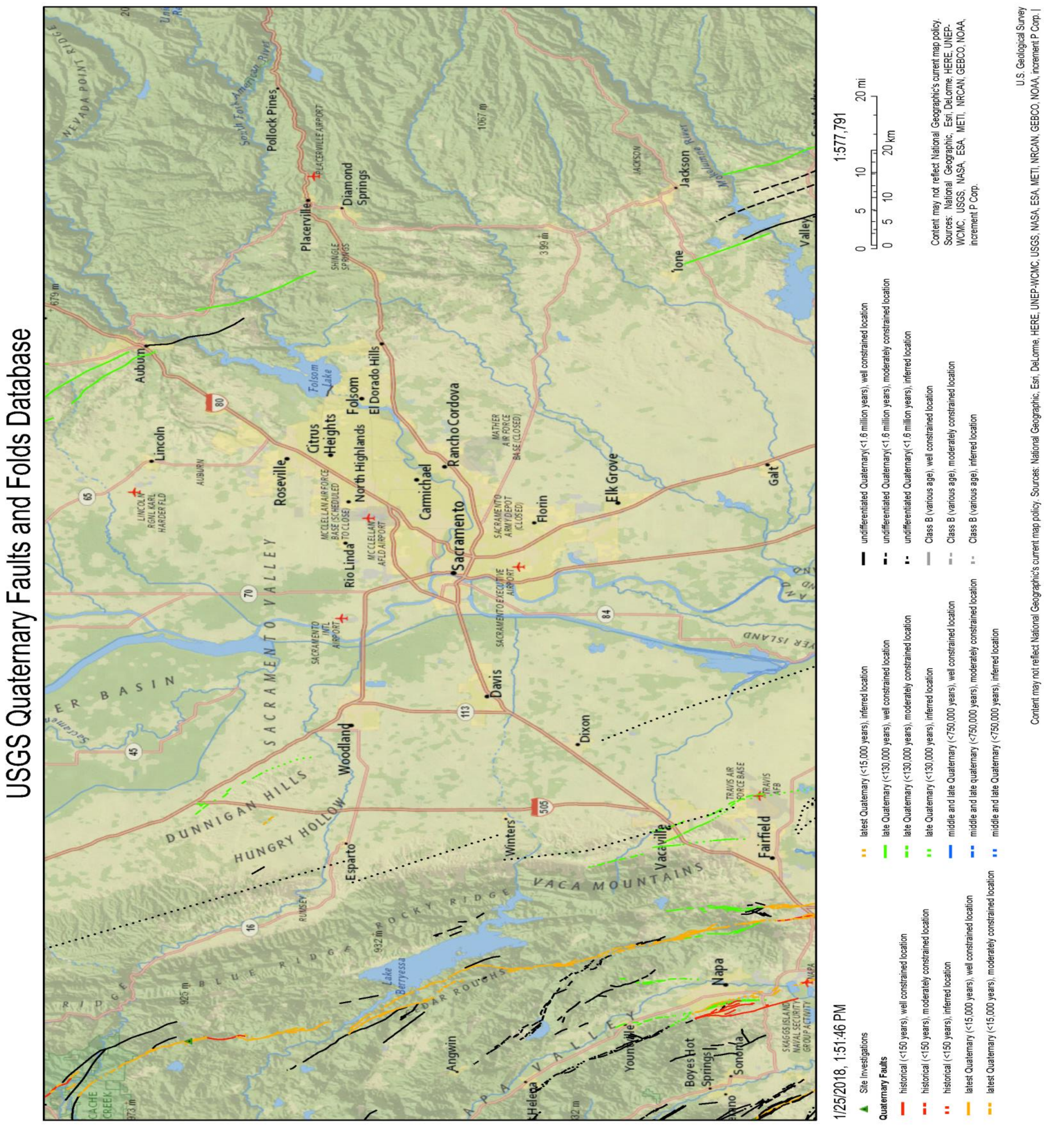

Figure 11 Sacramento Area Significant Faults

California's approximately 200-year recorded history is short, indeed, compared with the estimated 4.5 billion year age of the earth. It is a certainty that the Sacramento area has experienced violent earthquake motion during a part of this geologic time. From recorded information readily available for the past 200 years, however, it appears that Sacramento has not experienced violent earthquake motion of a nature compared with that experienced by several other areas within California.

Probably the greatest amount of earthquake shaking experienced in Sacramento during the recent past occurred on April 21, 1892. This earthquake produced extensive damage to towns some 25 miles west of Sacramento.

As noted above, the April 21, 1892 earthquake, along with the quake two days earlier, probably produced the most vigorous earthquake shaking in Sacramento during recorded history. There is some evidence that the epicenters of these shocks were in the area between Winters and Vacaville. Both of these towns, as well as Davis, Dixon, and Woodland experienced significant damage to many structures. Although the location for the fault responsible for the 1892 earthquakes is not known, the California Division of Mines and Geology and the U.S. Geological Survey have recently found (May 1972) that the Green Valley fault, west of Fairfield, is showing active fault creep or slip movements just to the south of Interstate 80 highway.

A lineament on the east flank of the Dunnigan Hills has been mapped recently by the U.S. Geological Survey. It may be the surface expression of a fault that has moved recently.

In recent time there was about $10,000 damage at the Sacramento Filtration Plant resulting from the Dixie Valley earthquake, east of Fallon, Nevada, December 16, 1954 - a Richter magnitude 7.2 earthquake. This was about 185 miles northeast of Sacramento and clearly indicates that the long period earthquake waves resulting from distant earthquakes can have definite effects upon structures or their contents. Damage also occurred to the digestion tanks at the Sacramento Sewage Treatment Plant and to a clarifier tank at the Campbell Soup Company.

There appears to be a strong northwesterly structural “grain” to California geology. Earthquakes having epicenters towards the west have not affected Sacramento in the past to the same extent as those centered east and south of Sacramento. The 1892 Winters earthquake appears to be an exception to the general statement. To explain further, the April 18, 1906, San Francisco shock of Richter magnitude 8.25 with its epicenter about 80 miles west of Sacramento was probably felt in Sacramento with about the same intensity as the Owens Valley quake of March 12, 1872, which has been estimated to be between 8.0 and 8.25 Richter magnitude and was about 230 miles southeast of Sacramento. Also, the Boca Reservoir earthquake of Richter magnitude 6.0 on August 12, 1966, 95 miles northeast of Sacramento was strongly felt in the Sacramento area as well as the above mentioned Dixie Valley earthquake 185 miles northeast of Sacramento.

The University of California Seismographic Station Reports that since 1932 there have been approximately 700 earthquakes of Richter magnitude 4 and greater in the area bounded between longitudes 118°W and 124°W and between latitudes 36.5°N and 40.5°N. In general, this area is from Eastgate, located in west central Nevada, to the Pacific Ocean and from south of Fresno to Redding. Also within this area there were approximately 90 earthquakes of magnitude 5 and some 15 earthquakes of magnitude 6 during this period.

As noted above, the distance of the closest fault to the UCD/MNRC site far exceeds the siting requirements of ANSI 15.7, Section 3.2, which states “no proposed facility shall be located closer than 400 meters from the surface location of a known capable fault.”

2.3 Major Highways

2.3.1 Industry

There are no major industrial facilities in the Sacramento area that need be of concern from the UCD/MNRC safety standpoint. The area’s economy is primarily based on agriculture and government with much smaller contributions by such things as mining, manufacturing of durable goods, lumber and wood products, and metal fabrication. The closest oil refinery is located at Martinez, California, approximately 85 miles to the southwest.

2.3.2 Transportation

2.3.2.1 Highway Transportation

The Sacramento area is at the cross-roads of two interstate highways: the transcontinental I-80, and N/S I-5. I-80 goes to San Francisco to the west, and to Reno to the east. Business 80 passes through the downtown area and connects with I-80 in west Sacramento, and in northeast Sacramento at Watt Avenue. Three main gates into the Industrial Park are located on Watt Avenue about a mile north of the I-80/Watt Avenue intersection.

Interstate 5 passes through downtown near the Sacramento River; traveling north, it leads to Oregon and Washington; south I-5 leads to Los Angeles and San Diego. U.S. Highway 50 links the downtown area to points east; Rancho Cordova, Folsom, El Dorado Hills, Placerville, and South Lake Tahoe. State Highway 99 generally parallels I-5 to southern California, joining I-5 south of Bakersfield.

2.3.2.2 Airports

As of 1983 there were 71 airports within the Sacramento Area Council of Governments, SACOG, the Region on which records were kept. Of those, 16 were public use, 53 were private, and two (including the former McClellan AFB) were military. Since the early 80's the use of the aircraft runways to present day, at the former McClellan AFB site, continued to involve military; however, it now includes commercial usage. The current usage of the runways is significantly less than the former military usage in the 80's. Additional information on the McClellan airfield usage can be found in chapter 2 of the MNRC SAR.

2.3.2.3 Water Transportation

Sacramento has the largest river system in California. A ship channel between Rio Vista and Sacramento was dredged by the Army Corps of Engineers where there was an existing lake area. It is the Port of Sacramento, operated by the Sacramento-Yolo Port district, and lies 79 nautical miles from the Pacific Ocean and approximately 11 miles from the UCD/MNRC.

Since its opening in 1963, the port has developed extensive cargo storage and handling facilities, largely focusing on rice, wheat, and wood chips commodities.

2.3.2.4 Rail Transportation

Union Pacific operates the tracks that parallel Roseville Road, and along the south-east corner of the Industrial Park. The closest approach to the reactor facility is approximately 3500 feet. Union Pacific connects Sacramento with 21 western, central, and southern states. On a daily basis there are nine scheduled AMTRACK passenger trains and fourteen freight trains that utilize the tracks just southeast of the reactor facility. All shipments aboard these trains are in accordance with the Code of Federal Regulations 49 CFR - Transportation. All normal shipments are not expected to threaten the reactor facility. The California State Office of Emergency Services has the UCD/MNRC listed as a critical facility for notification during planning of any hazardous material shipments along this route.

There are other feeder, connector and inter-tie services provided to the Sacramento area by Sacramento Northern and Central Traction Company and Western Pacific Railroad. However, these facilities are all to the south and beyond consideration.

2.4 Operational Boundaries

From the UCD/MNRC normal operations, safety, and emergency action standpoint there are two areas of concern (Figures 12-14). The first is the area inside the perimeter fence (with outriggers and barbed wire) surrounding the UCD/MNRC enclosure. This area is the exclusion area. It is a “restricted access” area and control of activities within this area during normal operations and emergencies is the responsibility of the UCD/MNRC Director/Emergency Director.

The second area of concern is the area outside the UCD/MNRC perimeter fence. The general public has free access to this area and direction of emergencies is by local city/county civilian authorities. This is defined as the unrestricted area. The closest urban area to the UCD/MNRC is about 3000 feet to the east, Watt Avenue.

The area definitions for purposes of addressing radiation exposure in Chapter 11 of the SAR are restricted and unrestricted areas. The operations boundary (i.e., the UCD/MNRC perimeter fence) is the boundary between these areas; inside the fence is the restricted area and outside the fence is the unrestricted area.

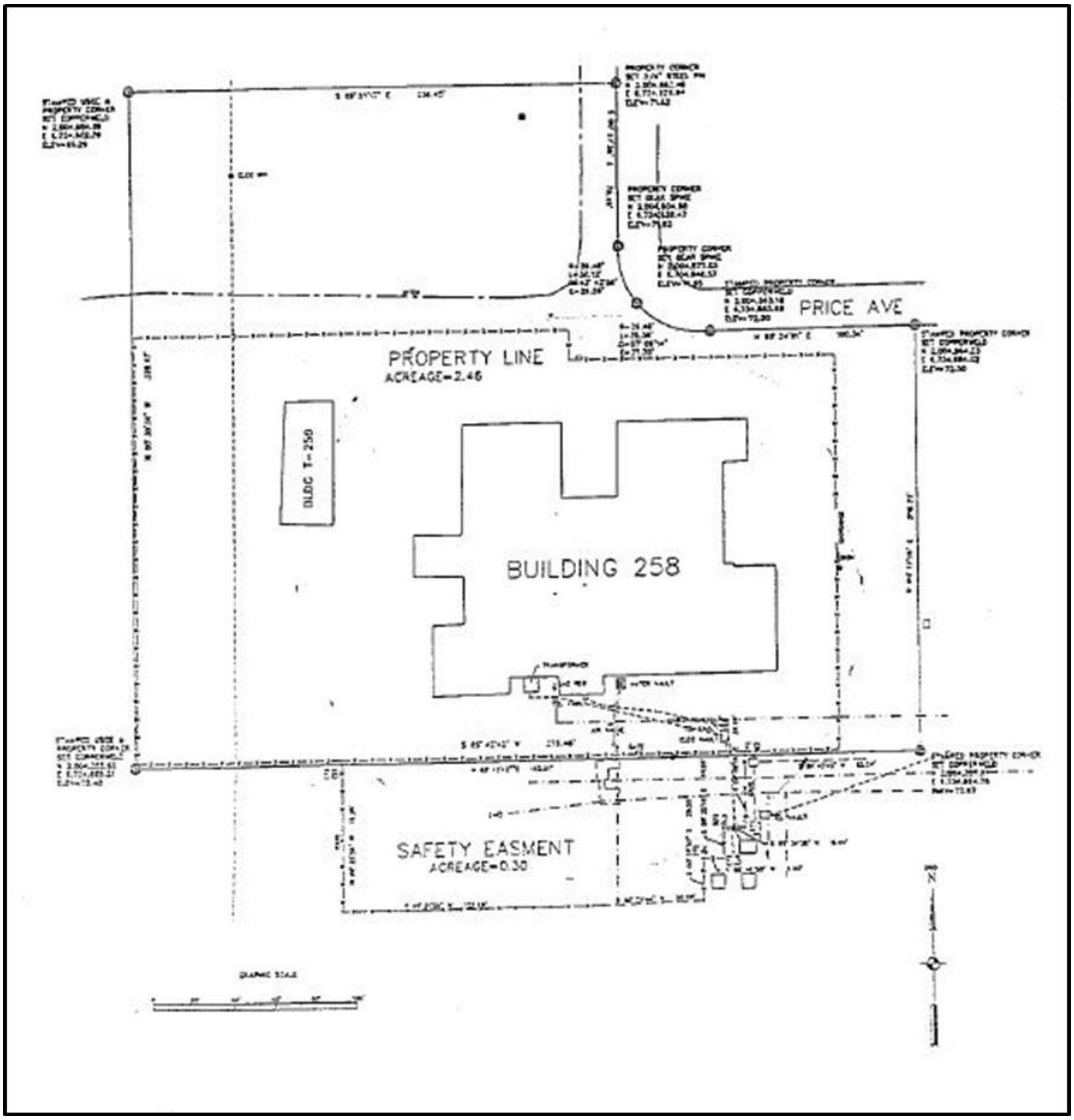

Figure 12 Operational Boundary of MNRC

Figure 13 Areal View of MNRC Operational Boundary

Figure 14 Alternate View of MNRC Facility and Operational Boundary

2.5 Climatology

2.5.1 Regional Climatology

Sacramento is situated in California's Central Valley between the Sierra Nevada and Coastal Range. The area is characterized by hot summers (July mean maximum temperature 105°F) and cold winters (January mean minimum temperature 28°F) (Reference [18]). As in most of California, the majority of the annual average precipitation, about 17 in. (40 cm), falls in the winter months as rain. The prevailing winds in the area are from the south to south-by- southeast.

The eastern most mountain chains form a barrier that protects much of California from the extremely cold air from the Great Basin in the winter. There are occasions when cold air from an extensive high pressure area spreads westward and southward over California. Even in these cases, the warming by compression as the air flows down the slopes of the mountains into the valleys prevents severe cold damage. The ranges of mountains to the west offer some protection to the interior from the strong flow of air off the Pacific Ocean. Between the two mountain chains and over much of the desert area the temperature regime is intermediate between the maritime and the continental models. Hot summers are the rule while winters are moderate to cold.

2.5.2 Local Meteorology

The summary of meteorological conditions for the UCD/MNRC site is based on the records obtained by officials of the National Oceanic and Atmospheric Administration, U.S. Department of Commerce and published in Volume II of "Climates of the States." The specific data, for the most part, is from the weather station at the Sacramento Executive Airport.

2.5.2.1 Temperatures

The normal and extreme temperatures for the Sacramento area are shown in Table 2-4. The normal temperatures are climatological standard normal (1931-1960). The normal daily minimum temperature of 37.2°F occurs in January and the normal daily maximum temperature, 93.4°F, occurs in July. Extreme temperatures have ranged from a low of 23°F in January of 1963 to 115°F in June of 1961.

2.5.2.2 Precipitation

The normal precipitation for the Sacramento area is 16.29 in./yr with the highest amounts, approximately 3.2 in. occurring in the months of December and January. The maximum monthly rainfall, 12.64 in., fell in December 1955. The maximum rainfall over a 24-hour period of time, 5.59 in., occurred in October 1962.

2.5.2.3 Humidity

The humidity in the Sacramento area range from a low of 28% in July to a high of 91% in December and January.

2.5.2.4 Winds and Stability

The annual wind rose for the Sacramento area is shown in Figures 15 and 16. The data to prepare these two wind roses was collected for the periods 1953-57 and 1992-96. As can be seen, the prevailing winds in the area are from the south to south-by-southeast.

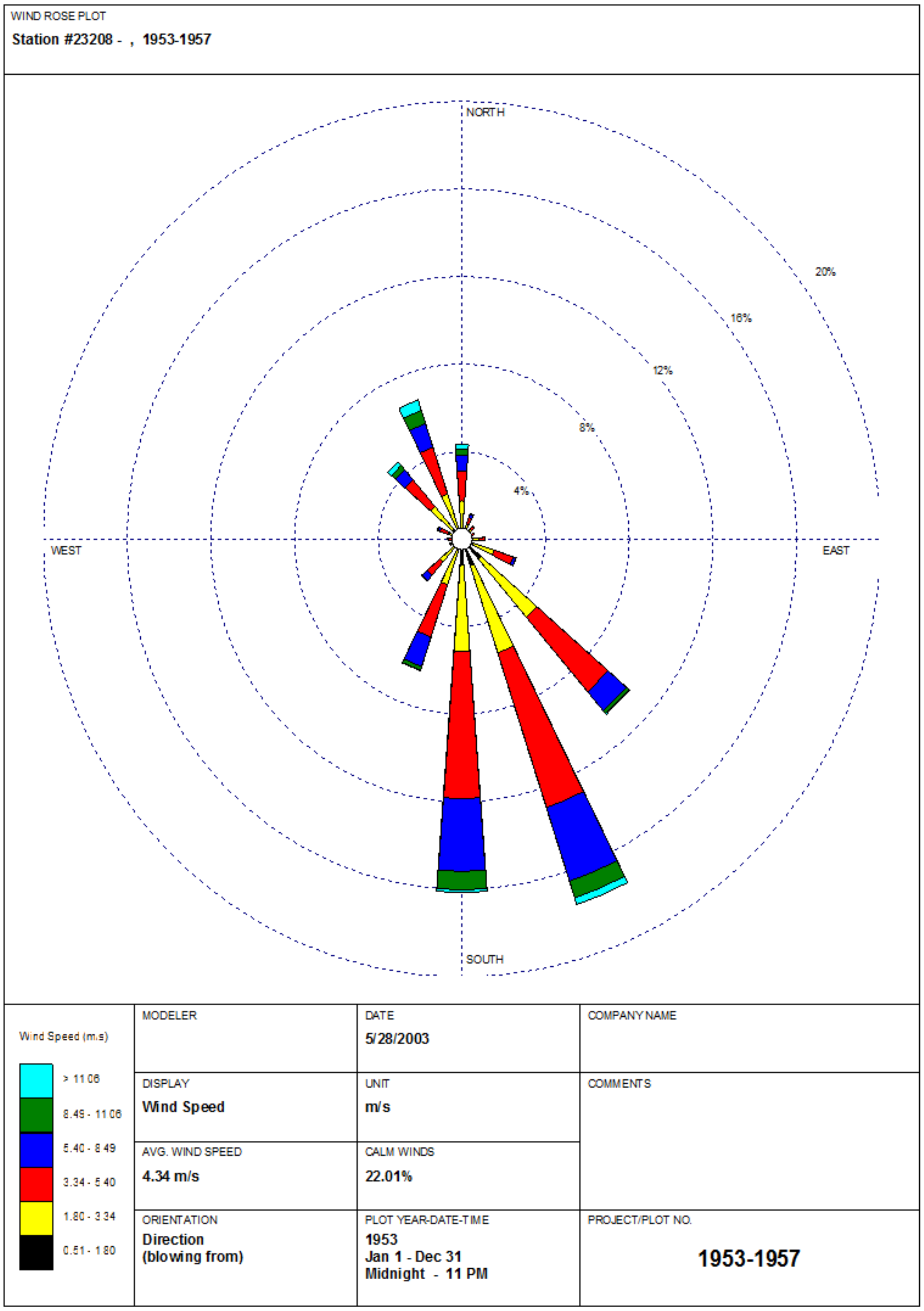

Figure 15 MNRC Area Wind Rose from 1953-1957

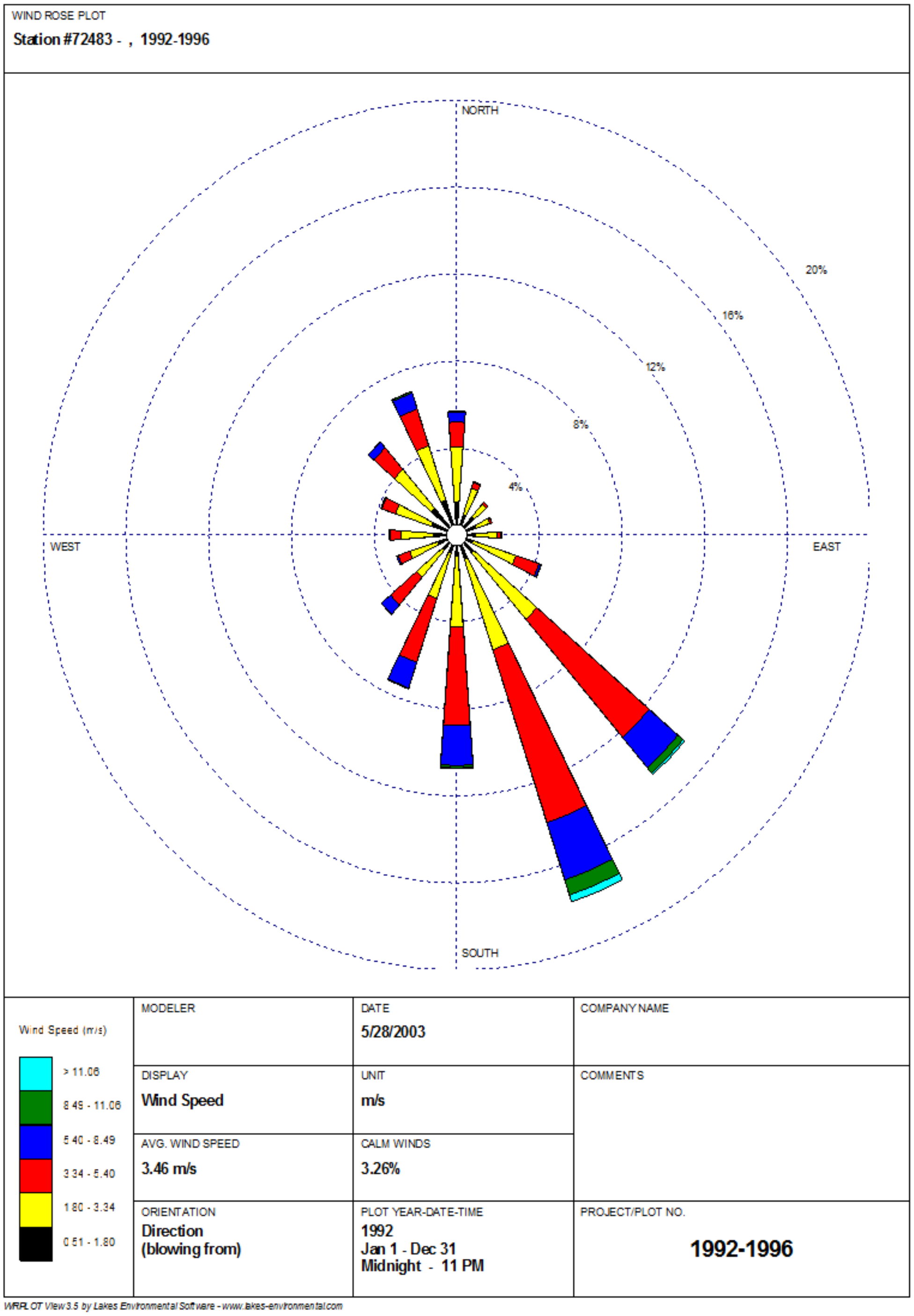

Figure 16 MNRC Area Wind Rose from 1992-1996

Table 2 Historical Temperature Data for Sacramento

Temperature							
Normal				Extreme			
Month	Daily Maximum	Daily Minimum	Monthly	Record High	Year	Record Low	Year
J	53.2	37.2	45.2	67	1966	23	1963
F	58.6	39.8	49.2	76	1964	28	1962
M	64.8	42.0	53.4	86	1966	28	1966
A	71.4	45.3	58.4	91	1968+	34	1967+
M	78.2	49.7	64.0	101	1967	37	1964
J	86.5	54.4	70.5	115	1961	43	1966
J	93.4	57.4	75.4	113	1961	50	1960
A	91.9	56.3	74.1	107	1968+	49	1966
S	88.2	55.0	71.6	104	1969+	43	1965
O	77.6	49.4	63.5	99	1963	38	1969+
N	64.2	41.6	52.9	87	1960	26	1961
D	54.6	38.1	46.4	72	1967	24	1965
YR	73.6	47.2	60.4	115	June 1961	23	Jan. 1963

2.5.2.5 Severe Weather

Tornadoes have been reported in California, but they are infrequent. They are generally not severe and most cases cause only minor damage to trees or light buildings. Hurricanes and significant tropical storms essentially do not occur in this region of the country.

3.0 Proposed Action

3.1 General Reactor Information

This Safety Analysis Report supports an application to the Nuclear Regulatory Commission (NRC) by the University of California - Davis (UCD) for the utilization of a steady-state 1000 kW TRIGA® fueled reactor with no pulsing capability. The reactor is owned and operated by UCD for neutron radiography and irradiation services for both university and non-university tasks. The facility is known as the University of California - Davis/McClellan Nuclear Research Center (UCD/MNRC).

3.1.1 Purpose of Facility

The UCD/MNRC provides a broad range of radiographic and irradiation services to the military and non-military sector. The facility presently provides four radiography bays and consequently four beams of neutrons for radiography purposes. In addition to the radiography bays, the UCD/MNRC reactor core and associated experiment facilities are completely accessible for the irradiation of material. These irradiation services include silicon doping, isotope production, both medical and industrial, and neutron activation analysis (e.g., geological samples). All four radiography bays are capable of using radiography film and digital image capturing techniques. All bays contain the equipment required to position parts for inspection as well as the radiography equipment. To meet facility use requirements, the reactor system and associated experiment facilities are designed to operate three shifts per day, though this mode of operation has not been utilized for well over a decade.

3.2 Reactor and Containment Systems

3.2.1 Building Structural Description

The UCD/MNRC reactor is housed in a building specifically designed for reactor operation. It includes the many systems needed to support this type of operation. The UCD/MNRC Reactor Facility consists of one building which houses the reactor, radiography bays, and support areas. The UCD/MNRC is a three-story facility. The exterior walls are constructed from reinforced concrete and block to a height of 24 ft, and the remaining superstructure is covered with corrugated steel. The roof is a weather-sealed steel deck. The interior walls of the radiography bays are constructed of reinforced standard concrete ranging from 2 to 3 ft thick. The roof of these areas is constructed of 2-ft thick reinforced concrete. The reactor room is constructed of standard reinforced concrete block with a built-up roof.

The structural design of the UCD/MNRC conforms to the Air Force General Design Criteria (AFM 88-15), the Uniform Building Code, the AISC Specifications, and to the ACI Code. The UCD/MNRC design seismic load is in accordance with Uniform Building Code Zone 3 criteria. The massive concrete walls and roof that surround the reactor tank provide protection from natural phenomenon. This, coupled with the fact that the reactor can withstand reactivity-insertion and loss-of-coolant accidents without release of fission products, and the low exposures associated with the design-basis accident, demonstrates that the structure is adequate for housing the UCD/MNRC reactor.

Fire detection and suppression systems have been installed throughout the facility. In addition, the instrument cabinets and the reactor and radiography control consoles have been equipped with fire suppression systems.

The reactor room and equipment room cranes have been designed and constructed in accordance with OSHA 29 CFR Part 1910.184, Overhead and Monorail Cranes. All parts have been designed for resultant static loads based on rated capacity with a factor of safety of at least five based on the ultimate strength of the material used. The fuel transfer cask lifting lugs have been designed using the ANSI/ASME code as guidelines. The design analysis shows a margin greater than six when the entire load of the cask is on one lifting lug. In addition, all of the fuel transfer hoisting equipment will be load tested, maintained and operated in accordance with ANSI/ASME during all fuel handling operations. This design, fabrication and testing approach coupled with the low exposures associated with fuel element clad failures shows that this system is adequate for its intended use.

The reactor is located in a cylindrical aluminum walled tank with the core positioned approximately 4.5 ft below grade (i.e., tank bottom is ~6.5 ft below grade). The reactor tank is surrounded by a monolithic block of reinforced concrete (figure 17 and 18). Below ground level, the concrete is approximately 11 ft thick. Above ground level, the concrete varies in thickness from approximately 10 ft to 3.25 ft with the smaller dimension at the tank top. The tank is supported by a concrete pad approximately 9.5 ft thick.

The basic purpose of the massive concrete structures is to provide biological shielding for personnel working in and around the UCD/MNRC. However, due to the massiveness of these structures, they provide excellent protection for the reactor core against natural phenomena.

The facility exhaust systems are designed to maintain the reactor room and radiography bays at a slightly negative pressure with respect to surrounding areas to prevent the spread of radioactive contamination. These systems also maintain concentrations of radioactive gases in the reactor room and the radiography bays to levels that are below the 10 CFR Part 20 limits for restricted areas. The reactor and radiography control rooms each have their own air handling systems.

There is a system of interlocks and warning devices to prevent personnel from inadvertent exposure to high radiation levels. Interlocks prevent personnel from entering the radiography bays whenever the beam tube shutters are open and the reactor is operating. This system also prevents the beam tube shutters from being opened when the reactor is operating and personnel are in the radiography bays when the bay doors are open. There are “Reactor On” lights throughout the facility that indicates the reactor operating status. Beam tube shutter positions are monitored in the reactor and radiography control rooms. Audible and visual alarms are sounded in the radiography bays when the shutters are opening. Manual and automatic reactor shutdown devices are located in the reactor room, and each radiography bay, so immediate reactor shutdown can be initiated by anyone occupying these areas should it become necessary.

The UCD/MNRC contains the electrical, water, and sewer utilities required for operation. In addition, the facility has both fire detection and suppression systems, intercom systems, radiation monitoring systems, security systems, parts positioning equipment, irradiation and radiography equipment.

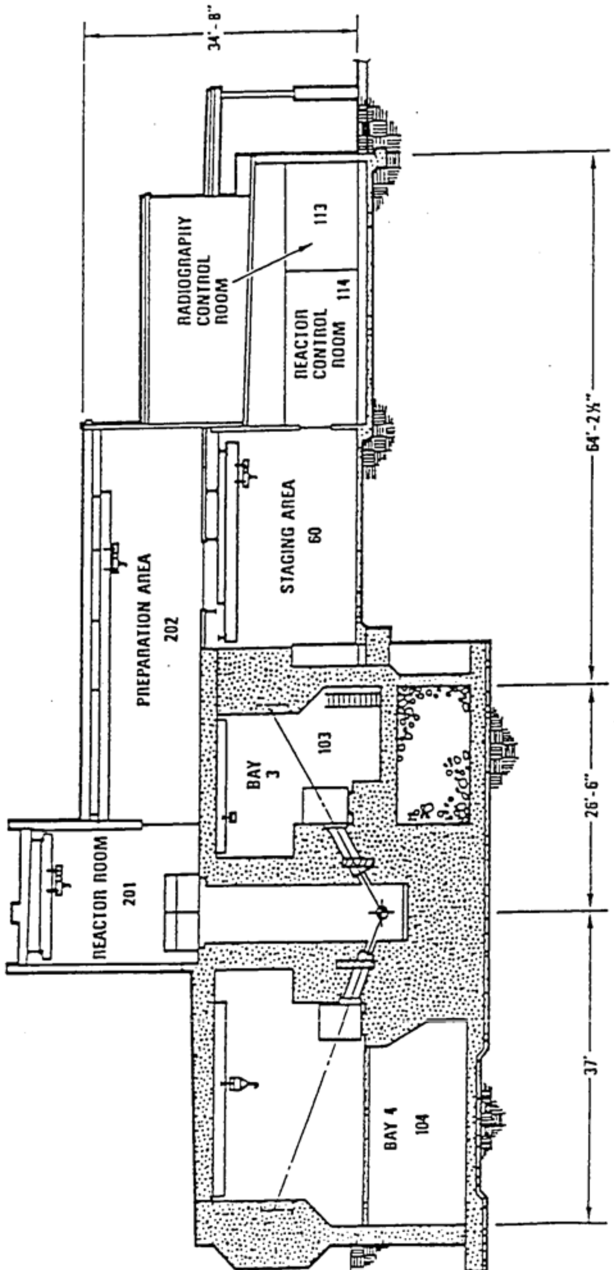

Figure 17 Cross Sectional View of MNRC Looking Into Bays 3 and 4

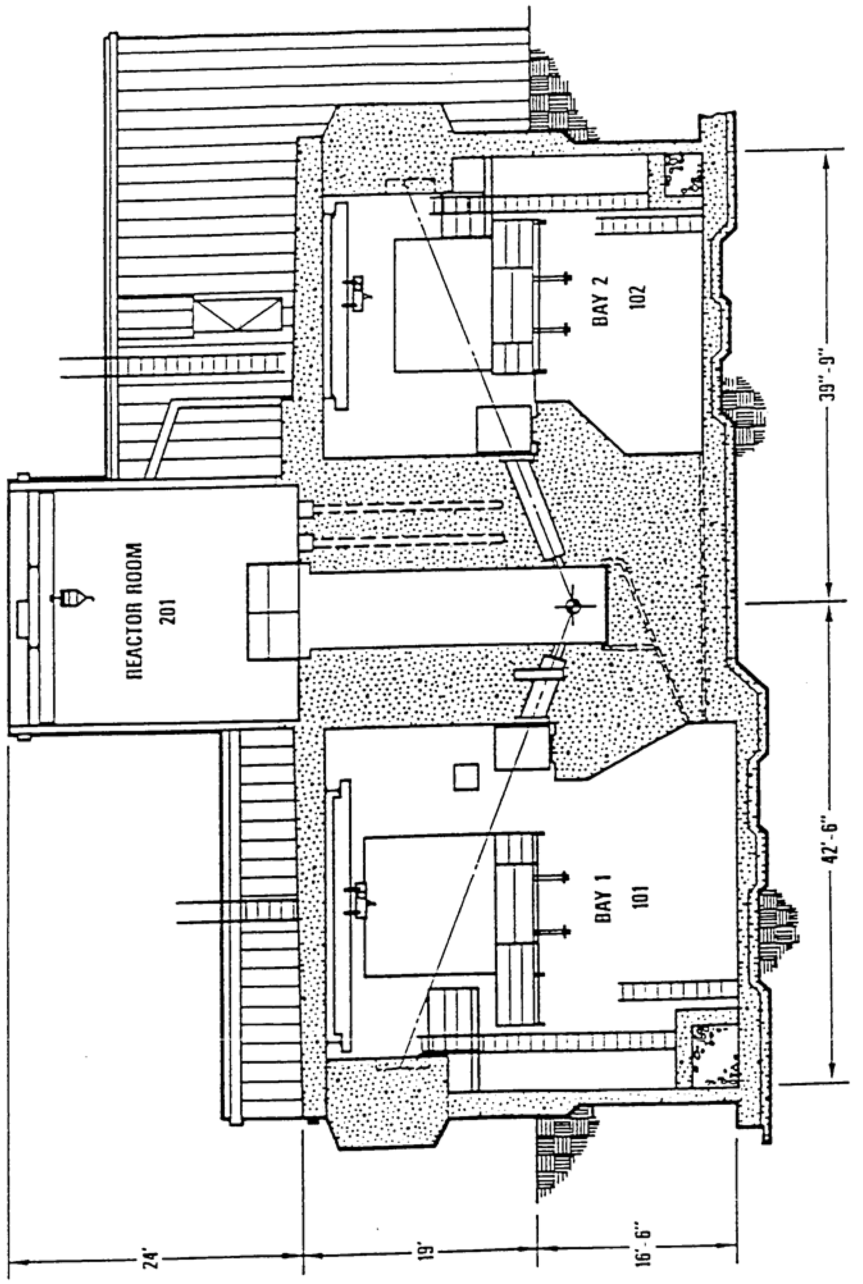

Figure 18 Cross Sectional View of MNRC Looking Into Bays 1 and 2

3.2.2 Reactor

The UCD/MNRC reactor is a 1.0 MW, natural-convection-cooled TRIGA® reactor with a graphite reflector presently designed to accept the source ends of the four neutron radiography beam tubes which terminate in four separate neutron radiography bays. The reactor is located near the bottom of a water-filled aluminum tank 7 ft in diameter and about 24.5 ft deep (Figure 19). Direct visual and mechanical access to the core and mechanical components are available from the top of the tank for inspection, maintenance, and fuel handling. The water provides adequate shielding for personnel standing at the top of the tank. The control rod drives are mounted above the tank on a bridge structure spanning the diameter of the tank. The reactor is monitored and controlled by a computer-based instrumentation and control system featuring color graphics display and automatic logging of vital information. Both manual and automatic control options are available to the operator.

The reactor console is located in the reactor control room and manages all control rod movements, accounting for such things as interlocks and choice of particular operating modes. It processes and displays information on control rod positions, power level, fuel temperatures, pulse characteristics, and other system parameters. The reactor console performs many other functions, such as monitoring reactor usage and storage of historical operating data for replay at a later time.

Fuel for the UCD/MNRC reactor is standard TRIGA® reactor fuel having 20%, or 30% by weight of uranium enriched to less than 20% 235U. TRIGA® reactor fuel is characterized by inherent safety, high fission product retention, and the demonstrated ability to withstand water quenching with no adverse reaction from temperatures to 1150°C. The inherent safety of TRIGA® reactors has been demonstrated by extensive experience acquired from similar TRIGA® systems throughout the world. This safety arises from the large prompt negative temperature coefficient that is characteristic of uranium-zirconium hydride fuel-moderator elements used in TRIGA® systems. As the fuel temperature increases, this coefficient immediately compensates for reactivity insertions. This results in a mechanism whereby reactor power excursions are limited/terminated quickly and safely.

Heat produced by the reactor core is removed by the primary and secondary cooling systems. The primary system circulates tank water through a water-to-water heat exchanger. The secondary water system gains heat in the heat exchanger and rejects it by use of a cooling tower. A purification system circulates a small amount of tank water through a filter and resin tanks to maintain purity and optical clarity. All of these systems contain the necessary instruments and controls for operations and monitoring performance.

3.3 Cooling and Auxiliary Water Systems

3.3.1 Reactor Tank

The reactor core is positioned near the bottom of an open 1/4 in. thick aluminum tank 7-1/2 ft in diameter by 24-1/2 ft high (Figure 19). The tank contains approximately 7,000 gallons of high-purity water so the core is clearly visible from the top. About 20 ft of water over the top of the reactor core provides biological shielding for personnel in the reactor room. The tank is imbedded in a massive concrete structure which provides biological shielding for personnel in surrounding areas.

Pipe assemblies welded to both the inside and outside of the tank wall (the tank wall is continuous), slightly above the reactor core, form one part of the beam tubes. Flanges have been welded to the pipe stubs on the inside of the tank and are used to attach the in-tank section of the beam tube. Clearance has been provided between the pipe stubs outside the tank and the reactor bulk shielding to prevent structural loading of the tank wall from thermal expansion. An aluminum angle used for support of fuel storage racks, underwater lights, and other equipment is located around the tank top.

The exterior surface of the tank is coated with epoxy and tar-saturated roofing felt to prevent corrosion. The felt is applied in a double thickness using a bituminous material. In addition, a corrugated liner, approximately 1 in. in thickness, is located between the tank exterior and the concrete shield. The corrugated liner provides a path for water to drain to a collection point under the tank should the tank overflow or leak. A drain around the base of the tank is designed to collect any water from the corrugated section. The drain is installed so that it can theoretically be routinely monitored for evidence of leakage.

The top of the reactor tank is closed by aluminum grating covers that are hinged. Lucite plastic is attached to the bottom of each grating section to prevent foreign matter from entering the tank while still permitting visual observation.

Tank materials, welding procedures, and welder qualifications were in accordance with the ASME code. The integrity of tank weld joints has been verified by radiography, dye penetrant checking, leak and hydrostatic testing.

There have been no known leaks of the reactor tank in the history of the facility.

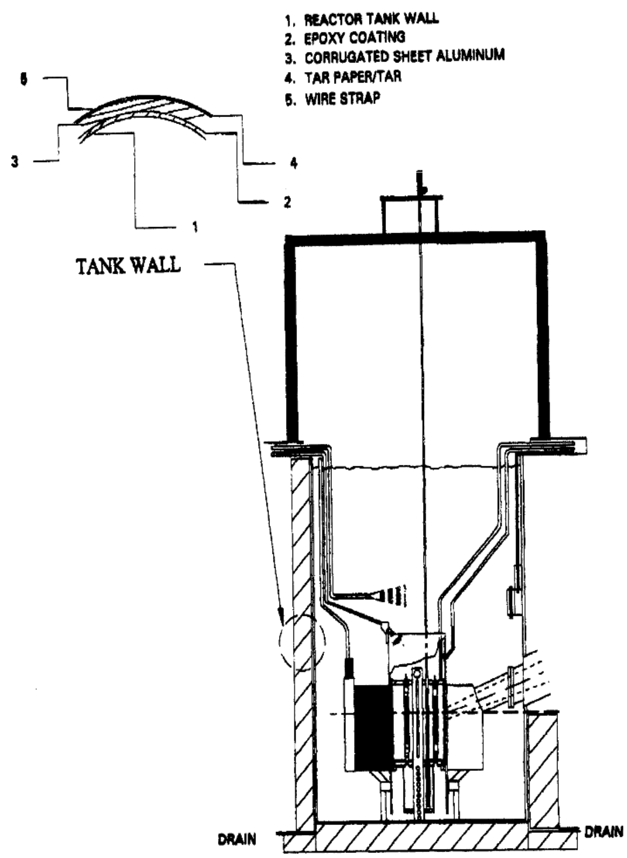

Figure 19 Cross Sectional View of Reactor and Reactor Tank

3.3.2 Primary Coolant System

The reactor core is cooled by natural circulation of the reactor tank water. The tank water temperature is maintained at approximately 90°F by the primary cooling system.

The primary cooling system, is designed to continually remove up to 3 MW of heat from the reactor tank. It contains the necessary equipment and controls to circulate up to 1000 gpm of tank water and maintain the temperature of the water returning to the tank at about 32.2°C (90°F). Instrumentation is provided to monitor the system operation, water temperatures, pressure, flow, and tank level. Tank bulk water outlet and inlet temperatures are continuously recorded.

This system is operated and monitored from the reactor control room. The remote controls and monitoring instrumentation are located in the reactor room. The system is regulated to maintain the primary water system pressure lower than the secondary system pressure. This pressure differential will prevent radioactivity from entering the secondary system, especially the cooling tower, should a leak develop between the two systems.

With the exception of pressure, system parameters are read out in the reactor control room. Alarms are provided on the reactor control console, if flow, tank bulk temperature, or tank water level exceeds preset limits. System pressure gages have local readouts. There is also a tank level indicator on the tank wall that is visible from the reactor room.

All system components that contact the primary water are normally made from either aluminum or stainless steel. The heat exchanger is a plate-type with the primary water flowing within the plates.

The entrance to the pump suction line is less than 3 ft below the normal tank water level. In addition, the line is perforated from about 8 in. below the normal tank water level to the entrance. Should a primary system component fail downstream of the pump, the tank water level would lower to the first perforation, about 8 in. At this point the pump should lose suction and quit pumping. However, in no case can the pump lower the water level beyond the entrance to the pump suction line, less than 3 ft. Even if the water level lowers to the entrance to the pump suction line there will be approximately 16-1/2 ft of water above fuel elements in the core. This feature prevents the loss of a significant amount of tank water should a leak develop in any of the primary system components when the pump is operating.

3.3.3 Secondary Coolant System

The secondary cooling system is capable of continually removing 3.0 MW of heat from the primary system during normal weather conditions. The system circulates approximately 1000 gpm of water from a cooling tower through the primary-to-secondary heat exchanger and back to the cooling tower. The pressure of the secondary system is maintained higher than the primary system to prevent cross contamination of secondary water should a leak develop in the heat exchanger.

Water chemistry, conductivity, and pH are monitored and maintained by an automatic water conditioning system that adds chemicals as required.

3.3.4 Reactor Water Purification Systems

The reactor water purification systems maintain the primary water purity and optical clarity. There are two separate systems that can be operated independently or can be cross-connected to operate as one unit. One system is used to filter particulate matter from the surface of the reactor tank and the other system deionizes the water to maintain the purity.

The filtration system uses a drum surface skimmer that floats near the surface of the water in the reactor tank. A pump moves water from the surface skimmer to fiber cartridge filter elements. These filter elements remove any dirt or debris from the reactor tank water by mechanically filtering them from the water before returning the water to the reactor tank. The system can be used to return the filtered water directly to the reactor tank or, through a series of valve manipulations, it can send the filtered water through the deionizers and then back to the reactor tank. The system is used to supply the deionizing resin bed during extended shutdown periods when the primary cooling system is not operational.

A set of deionizing resin beds (four) are supplied from the primary cooling system (outlet of the heat exchanger) at a nominal flow rate of eleven gallons per minute (11 gpm). The resin bed consists of four fiberglass canisters of mixed-bed resin. Two of the canisters are normally on-line and the other two canisters are in a stand-by condition. Two conductivity cells are used to measure the conductivity of water entering the resin beds and the conductivity of the water exiting the resin beds subsequent to entering the reactor tank. There are local readouts of the conductivity near the resin tanks and remote readouts and alarm functions located on the reactor console.

Pressure gauges are located within the systems to monitor the overall performance of the systems.

3.3.5 Primary Coolant Makeup Water System

A 300 gallon plastic tank of demineralized water is available to make up any primary cooling system water lost by evaporation or other means. The makeup system is equipped with a positive displacement pump and resin canister of the same type that are used in the purification system. The outlet flow of the makeup system discharges to the purification system.

3.4 Radioactive Waste

It is MNRC policy to minimize the release of radioactive liquid waste. Because normal MNRC operations create only small volumes of liquid which contain radioactivity, it has been possible to convert the liquids to a solid waste form and thus adhere to facility policy. In special cases, the MNRC may generate a large volume of radioactive liquid waste which cannot be converted to a solid waste. In these cases, disposal by the sanitary sewer in accordance with 10 CFR 20 may be required. However, routinely MNRC does not release any radioactive waste into the sanitary sewer.

As with most non-power reactors, solid waste is generated from reactor maintenance operations and irradiations of various experiments. Most solid waste consists of spent resin and used encapsulations from experiment irradiations. No solid radioactive waste is intended to be retained or permanently stored on site.

Appropriate radiation monitoring instrumentation will be used for identifying and segregating solid radioactive waste. Radioactive waste is packaged in metal drums or boxes within the restricted area of the MNRC and is temporarily stored in a weatherproof enclosure within the MNRC site boundary until shipment for disposal or transfer to a waste broker. Typically a single routine “B-25 box” shipment is made every 5 years containing approximately 100 mCi.

As stated previously, minimization of radioactive waste is a policy of the MNRC. Although there are no numerical volume goals set due to the small volume of waste generated at the MNRC, the radiation safety officer and the reactor supervisor periodically assess operations for the purpose of identifying opportunities or new technologies that will reduce or eliminate the generation of radioactive waste. All new proposed experiments are reviewed. Part of this review is to evaluate the amount of radioactive waste the proposed experiment would generate. Proposed experiments can be modified or rejected if they produce unacceptably large amounts of radioactive waste.

3.5 Non-radioactive waste

Non-radioactive waste at MNRC is relatively small as the facility has no wet chemistry laboratories. The chemical operations at MNRC are closer in scope to that of a machine shop. Universal waste (batteries and fluorescent lights) are disposed of at a locally licensed waste disposal facility. Oil rags are accumulated and disposed of in accordance with local and state regulations. All other non-radioactive waste is disposed of by the main UC Davis safety services. Mixed waste is typically not generated at MNRC.

The secondary system water quality is maintained using 3 commercial products using containing hazardous materials. These products are the same or similar to those used in the air conditioning cooling towers of industrial facilities or large office buildings. These chemicals are bromine (30 gallons/year), a biocide (15 gallons/year), and a descaler (30 gallons/year). These materials are stored and used in accordance with all local state, and federal regulations.

Although there are no numerical volume goals set due to the small volume of non-radioactive waste generated at the MNRC, facility management is continuously identifying opportunities or new technologies that will reduce or eliminate the generation of non-radioactive waste and minimize carbon emissions (e.g. elimination of mercury based lighting, use of solar panels, etc.).

3.6 Fuel, facility lifetime, and maintenance

Routine maintenance performed on facility systems and components is necessary for safe and reliable operation of the reactor. Some of the maintenance activities conducted at MNRC includes inspection, testing, and surveillance to maintain the current licensing basis and ensure compliance with environmental and occupational safety requirements. The results of these activities are recorded, retained and trended. The MNRC Technical Specifications contain the surveillance requirements for the following key systems: containment system, cooling systems, control rod system, reactor instrumentation, fuel elements and auxiliary systems. These surveillance requirements contain acceptance criteria that must be met to assure proper operation of the respective systems. There are Limiting Conditions for Operation (LCOs) associated with failure to meet the acceptance criteria.

The MNRC is the second newest research reactor in the United States. The majority of TRIGA reactors in the US were built in the late 1960s. While many of these reactors have been shut down and subsequently decommissioned, this was done so for programmatic and financial reasons, not due to a specific finite design lifetime. With proper maintenance and sufficient fuel the MNRC be operated safely and secure through the duration of the proposed license renewal.

While there is currently no source of unused TRIGA fuel in the world, the MNRC possesses sufficient fuel to operate the reactor at a reduced power level (500 kW) for the duration of the proposed license renewal. This reduced power level would have some effect on in-tank experiments, but little effect on the facilities primary mission of outreach, education, and neutron radiography.

3.7 Refurbishment

There are no major construction activities or modifications that are required to support the license renewal request. Furthermore, no major modifications are anticipated during the license renewal term.

3.8 Employment

MNRC employs approximately 8-12 people on its full-time staff. In addition to this there are often external users working at the MNRC on a temporary basis. Due to the fact no major modification or refurbishment activates are planned for the period of the license renewal, there will be no need to have a significant contractor workforce on site.

4.0 Environmental Consequences of the Proposed Action

4.1 Assessment of NUREG-1437 Category 2 and Unclassified Issues

4.1.1 Water Use Conflicts

There are no potential water use conflicts caused by the continued operation of the MNRC for an additional 20 years. MNRC has a closed primary cooling loop that removes heat from the reactor via natural convection flow. A secondary coolant system is attached to the primary coolant system via a plate style heat exchanger. The primary system is maintained at a lower pressure than the secondary system to avoid the release of radioactive material to environment in the event of a cooling boundary failure. Heat is removed from the secondary system by a large evaporative cooling tower. The MNRC reactor is typically operated at 1.0 MW for neutron radiography which requires approximately 8 gpm makeup water to the secondary system. The water used for makeup is obtained from the Sacramento Suburban Water District which in turn obtains the water from approximately 30% wells and 70% snow runoff stored in regional reservoirs.

Typically the facility operates at 1.0 MW for 25-35 hours per week to support neutron radiography operations requiring approximately 8 gpm to maintain reactor tank temperature via the evaporative cooling system. The facility uses approximately 5 gpm of potable water for all other uses combined. This usage represents a meniscal fraction of the total water usage in the Sacramento Suburban Water District. In the event emergency core cooling is required a supply of 4,600 gallons is maintained on site. If this emergency supply was somehow unavailable, cooling water from the Sacramento Suburban Water District would be needed at a rate of 20 gpm for 3.7 hours per the MNRC technical specifications. This water usage would have no impact on the surrounding areas and the scenario requiring the usage is very unlikely to ever occur. Therefore, there is no potential for water use conflicts due to the continued operation of MNRC during the license renewal term.

4.1.2 Entrainment of Fish and Shellfish

Potential environmental impacts due to entrainment of fish and shellfish are not applicable to the present or continued operation of MNRC. Adverse impacts are caused by entrainment on screens or filters at plant intakes for cooling water. This issue is only applicable to nuclear power plants that draw cooling water from large natural bodies of water. MNRC does not draw any cooling water from a natural body of water. As such, it does not have an intake structure. All water is obtained from the local water district. Therefore, entrainment of fish or shellfish is not possible. This issue is not a concern applicable to the present or continued operation of MNRC.

4.1.3 Impingement of Fish and Shellfish

Impingement of fish and shellfish is not a concern for the present or continued operation of MNRC for the reasons that entrapment of fish and shellfish is not a concern as described in Section 4.1.2 above. MNRC does not use water obtained from a body of surface water containing fish or shellfish.

4.1.4 Heat Shock

MNRC does not discharge heated water to a body of surface water. MNRC uses a two loop cooling system that dissipates heat through evaporative losses to the atmosphere through a mechanical draft cooling tower. Thus, there is no potential for heat shock to impact aquatic ecology.

4.1.5 Groundwater Use Conflicts for Potable and Service Water

Plants that use more than 100 gpm taken from groundwater have a potential impact if the groundwater source is limited. The MNRC is requesting to be licensed to operate at 1.0 MW 24 hours a day 7 days a week. Even under these conditions the MNRC would use approximately 13 gpm total (8 gpm reactor cooling and 5 gpm for all other uses). As the MNRC typically operates at 1 MW for only one shift, a more likely water consumption is 13 gpm 25 to 35 hours per week. This places the actual average yearly consumption around 3 gpm. Sacramento Suburban Water District can produce just over 93,000 gpm from groundwater sources.

Therefore, there are no potential groundwater use conflicts resulting from water usage, either for secondary coolant make-up or potable water use. MNRC's total water usage is much less than 100 gpm during normal operations. No changes or modifications are anticipated during the license renewal term that will increase water usage at MNRC.

4.1.6 Groundwater Use Conflicts-Cooling Towers with Small Makeup Source

MNRC uses a mechanical draft cooling tower to remove heat from the secondary coolant system. This tower dissipates heat to the atmosphere along with small quantities of water (maximum of 8 gpm during 1.0 MW operation). The total usage by the cooling tower is negligible compared to the capacity of the local water supply (combination of aquafer and reservoirs) used to supply make-up water to the facility. Therefore, there are no potential groundwater use conflicts resulting from the present or continued operation of MNRC.

4.1.7 Groundwater Use Conflicts-Use of Ranney Wells

This issue is not applicable to MNRC because the facility does not use radial collector (Ranney) wells as part of its operation.

4.1.8 Degradation of Ground Water Quality

MNRC draws water from the Sacramento Suburban Water District. This water is used only for makeup to the secondary cooling system that dissipates heat and water vapor to the air and for potable water use. The facility does not have a cooling pond and does not discharge water to a body of surface or ground water. Waste water is treated by Sacramento County Water District and released into the Sacramento River where it is ultimately discharged to the San Francisco Bay. The volume of water discharged by MNRC daily constitutes a negligible percentage of the volume of water processed by the treatment plant each day. In addition, the volume of water released by the sewage treatment plant represents an insignificant increase in Sacramento River's flow. Therefore, the present or continued operation of MNRC has no impact on ground water quality.

4.1.9 Impacts of Refurbishment on Terrestrial Resources

There are no plans for significant refurbishment activities or modifications to MNRC related to license renewal and only minor upgrades are anticipated during the license renewal term. No major construction activities related to license renewal are planned. In addition, the only modifications or refurbishment activities anticipated during the license renewal term are minor enhancements related to facility maintenance. Therefore, there is no potential impact on terrestrial resources related to the present or continued operation of MNRC.

4.1.10 Threatened or Endangered Species

According to the United States Department of the Interior there are 6 threatened and one endangered species located in the greater Sacramento Area. The species are as follows:

- Giant Garter Snake Thamnophis gigas (Threatened)
- California Red-legged Frog Rana draytonii (Threatened)
- California Tiger Salamander Ambystoma californiense (Threatened)
- Delta Smelt Hypomesus transpacificus (Threatened)
- Valley Elderberry Longhorn Beetle Desmocerus californicus dimorphus (Threatened)
- Vernal Pool Fairy Shrimp Branchinecta lynchi (Threatened)
- Vernal Pool Tadpole Shrimp Lepidurus packardi (Endangered)

None of these species' habitats are located within the MNRC boundary. The location of these habitats ranges from several miles to several tens of miles. There are no plans to conduct any activities at MNRC that would be capable of resulting in degradation to these threatened/endangered species habitats, such as increasing water usage, increasing effluence to the sanitary sewer, or altering rainwater runoff. Thus, there is no impact on threatened or endangered species caused by the continued operation of MNRC during the license renewal term.

4.1.11 Air Qualify During Refurbishment

MNRC has no plans for major refurbishment or modification activities associated with license renewal. All anticipated construction activities to be performed during the license renewal term are related to facility maintenance or minor upgrades to equipment. Thus, there is no adverse impact on the environment due to the operation of MNRC and no impact on air quality resulting from the license renewal of MNRC.

4.1.12 Impact on Public Health of Microbiological Organisms

MNRC does not use a once-through cooling water system and does not have a cooling pond. Water is discharged from the facility into the sanitary sewer system. Non-contaminated water is evaporated into the atmosphere as a result of the cooling tower's operation via a secondary cooling system. The amount of water lost to the atmosphere is equivalent to the losses experienced by the cooling towers of industrial sites, large office buildings, or large residential buildings.

The secondary coolant system water quality is maintained using three commercial products containing hazardous chemical compounds that are commonly used in the air conditioning cooling towers of large office buildings. These chemical compounds include two biocides and a descaler.

Approximately 30 gallons of bromine and 15 gallons of the other biocide, 30 gallons of the descaler are used annually in the secondary coolant water. The secondary coolant system is essentially a recirculation loop, so much of the water and the chemical compounds are retained in the system. However, the chemically treated water enters the environment through evaporation at the cooling tower and through an overflow line that is routed to the sanitary sewer. These chemical compounds are approved for use. Their use does not represent a significant environmental impact.

Therefore, there is no potential impact on public health due to the growth of microbiological organisms in the water released from the facility (or the chemicals used to control the growth of microbiological organisms) during MNRC's present or continued operation.

4.1.13 Electromagnetic Fields-Acute and Chronic Effects

MNRC does not generate electricity and has no transmission lines coming into or out of the facility. Therefore, there is no potential for acute or chronic effects from the presence of electromagnetic fields caused by the present or continued operation of MNRC.

4.1.14 Housing Impacts

There are two aspects of potential impact on housing that must be assessed, impacts during refurbishment and impacts during the license renewal term. With respect to housing impacts during refurbishment, MNRC is planning no major refurbishment activities related to license renewal. Any modifications performed during the license renewal term that are required to maintain the facility and upgrade equipment will be accomplished with the existing work force and/or with a very limited number of contracted workers. Because the size of the work force will not be increased, there will be no significant impact on the housing market.

In addition, with respect to the license renewal term, there are no plans to significantly increase the size of the permanent staff at MNRC during the license renewal term. If there are any unexpected increases in staff, the size of MNRC's staff will continue to make up a small percentage of the local areas total population. As such, there are no potential impacts on housing due to the present or continued operation of MNRC.

4.1.15 Public Utilities-Public Water Supply Availability

MNRC uses a mechanical draft cooling tower to remove heat from the secondary coolant system. This tower dissipates heat to the atmosphere along with small quantities of water (maximum of 8 gpm). The cooling mechanism is the largest user of water at the MNRC.

The MNRC is requesting to be licensed to operate at 1.0 MW 24 hours a day 7 days a week. Even under these conditions the MNRC would use approximately 13 gpm total (8 gpm reactor cooling and 5 gpm for all other uses). As the MNRC typically operates at 1 MW for only one shift, a more realistic water consumption is 13 gpm for 25 to 35 hours per week. This places the actual average yearly consumption around 3 gpm. Sacramento Suburban Water District can produce just over 93,000 gpm from groundwater sources.

Therefore, there are no potential groundwater use conflicts resulting from water usage, either for secondary coolant make-up or potable water use. MNRC's total water usage is much less than 100 gpm during normal operations. No changes or modifications are anticipated during the license renewal term that will increase water usage at MNRC. Therefore, there is no impact on the public water supply availability due to the present or continued operation of MNRC.

4.1.16 Education Impacts from Refurbishment

MNRC does not plan any major refurbishment activities or modifications to the facility as part of the license renewal. In addition, MNRC does not plan on any significant increase in the size of its staff during the license renewal term. All modifications or refurbishment type upgrades that are likely to be implemented during the license renewal term will be performed by the existing staff along with a limited number of contracted personnel. There will be no increase in the number of students entering the surrounding school district (San Juan and Twin Rivers School District) due to continued operation of the facility. Therefore, there is no impact on education caused by any refurbishment activities that might take place during the license renewal term.

4.1.17 Offsite Land Use

The MNRC staff consists of approximately 10 FTE and is unlikely to ever exceed 12 FTE. The UCD/MNRC is situated approximately 8 miles (13 km) north-by-northeast of downtown Sacramento, California. Sacramento county has a population of about 1,418,788 (2010 census) , an increase of about 23% since the 1992 census which reported a population of about 1,093,000, which was in turn an increase of about 26% since 1970 (References [19], and [20]). The major population center of Sacramento lies south-by southwest of the McClellan Business Park. Because the number of people employed at MNRC represents an insignificant percentage of the surrounding area population, there is no impact on housing or other off-site land use due to the presents or continued operation of MNRC.

In addition because of the very small number employees at MNRC relative to the surrounding population the local and state tax revenue will remain essentially unchanged if the MNRC remains open or terminates operations.

There is also no significant impact on tax bases or revenue due to the continued operation of MNRC and no resulting change in off-site land use that could occur due to the increased tax revenues generated by the facility or its employees.

4.1.18 Transportation

The Sacramento area is at the cross-roads of two interstate highways: the transcontinental I-80, and N/S I-5. I-80 goes to San Francisco to the west, and to Reno to the east. Business 80 passes through the downtown area and connects with I-80 in west Sacramento, and in northeast Sacramento at Watt Avenue. Three main gates into the Industrial Park are located on Watt Avenue about a mile north of the I-80/Watt Avenue intersection.

Interstate 5 passes through downtown near the Sacramento River; traveling north, it leads to Oregon and Washington; south I-5 leads to Los Angeles and San Diego. U.S. Highway 50 links the downtown area to points east; Rancho Cordova, Folsom, El Dorado Hills, Placerville, and South Lake Tahoe. State Highway 99 generally parallels I-5 to southern California, joining I-5 south of Bakersfield.

The above mentioned 4 major highways/interstates are the primary route for the hundreds of thousands of daily vehicles for the Sacramento metro area. The MNRC staff is approximately 10 individuals and makes up less than 1/100,000th of the total population of the Sacramento Metro area. There are no plans for any major refurbishment activities related to license renewal and only minor modifications or refurbishment during the license renewal term. As such, there is no significant impact on transportation in the area due to the present or continued operation of MNRC.

4.1.19 Historical and Archaeological Resources

MNRC is situated on a ~2.4 acre lot located on the east side of the former McClellan AFB runway. MNRC has only the main reactor building and a temporary office trailer located on the site. No other buildings associated with MNRC are located outside of this 2.4 acre site.

There are no buildings or sites of historical or archaeological importance, located on the facility site. In addition, MNRC is not planning any major refurbishment activities or modifications to support the license renewal of the facility or during the term of the license. Only minor refurbishment activates and equipment maintenance are anticipated during the term of the renewed license. None of these refurbishment activities will involve construction activities that could disturb previously undisturbed land. Therefore, there is no potential for an impact on historical or archaeological resources due to the continued operation of MNRC.

4.1.20 Severe Accident Mitigation Alternatives

NUREG- 1537 (Reference [21]) identifies nine postulated accident events or categories that are applicable to research reactors.. The consequences of each of these nine postulated accident events or categories must be evaluated to determine the potential environmental impacts. They are as follows:

- Maximum Hypothetical Accident
- Insertion of Excess Reactivity
- Loss of Primary Coolant
- Loss of Primary Coolant Flow
- Mishandling or Malfunction of Fuel
- Experiment Malfunction
- Loss of Electrical Power
- External Events
- Mishandling or Malfunction of Equipment

Each of the above postulated accident events or categories have been evaluated and the results of the evaluation are presented in Chapter 13 of the MNRC SAR. Based on the results presented in Chapter 13, the Maximum Hypothetical Accident (MHA) leads to consequences worse than any other postulated accident. The MHA for all TRIGA reactors is accepted to be the failure of a single element in air after the reactor has operated at full power for an extended period. In the case of MNRC this period is assumed to be one year.

The MHA's radiation source term is comprised of Iodine and Noble Gas isotopes, including I-131, I-132, I-133, I-134 I-135, Kr-85, Kr-85m, Kr-87, Kr-88, Kr-89, Kr-90, Xe-133, Xe-135, Xe-135m, Xe-137, Xe-138, and Xe-139. Detailed calculations that use the conservative assumptions outlined in the SAR demonstrate that the maximum radiation dose that would be received by an individual inside the Reactor Room are:

Table 3 Reactor Room Radiological Consequences of MNRC Maximum Hypothetical Accident (MHA)

Accident: Cladding Failure in Air (MHA)		
	CDE Thyroid (millirem)	**TEDE (millirem)**
2 minute room occupancy	998	120
5 minute room occupancy	2,495	300

The doses given above are well below the applicable 10 CFR 20 dose limits for a radiation worker may receive in a year.

The MHA will result in radioactive material being vented to the atmosphere, resulting in some exposure to the general public. These doses are provided below.

Table 4 Off-Site Radiological Consequences of MNRC Maximum Hypothetical Accident (MHA) with Worst-case Atmospheric Conditions

Distance (Meters)	**CDE Thyroid (millirem)**	**TEDE (millirem)**
33 (fence line)	46	2.3
93 (closest inhabited building)	38	1.8
480 (closest residence)	16	0.7

The public doses given above are below the applicable 10 CFR 20 limits for the dose a member of general public may receive in a year. It is important to note the calculations used to estimate potential public dose from the MHA are very conservative. Most notably it was assumed that the radioactive materials are released from the reactor room floor (~19 foot elevation). In reality if the MHA were to occur, the radioactive material would be released up a 60 foot stack and be substantially diluted before reaching the public. Therefore, the public doses given above is likely dramatically overestimated.

4.1.21 Transportation and Storage of Radiological Waste

Spent fuel generated during the operation of MNRC is either stored in the reactor pool or the spent fuel pits inside the reactor room. The fuel is owned by the DOE and will ultimately be shipped to a disposal site maintained by the DOE. Irradiated fuel remains in the reactor pool or the spent fuel pits until it is loaded into an NRC approved cask for shipment.

Spent fuel must be cooled in water before it may be transferred to an air environment (either the spent fuel storage pit or shipping casks). Due to the relatively low flux of the reactor, decay heat of the fuel elements is relatively low. Furthermore, on average the MNRC reactor only produces 2 spent fuel elements per year. Therefore, any fuel transportation to DOE will occur very rarely, leaving a long preparation time to ensure fuel has been given sufficient time cool down.

MNRC currently stores spent fuel onsite only until the criteria for shipment are satisfied and a cask can be prepared for shipment to DOE facilities. In fact such shipments are only needed every 20 or so years of operation. There are no environmental impacts from this short-term storage of irradiated fuel due to the shielding provided by the water in the reactor pool and the concrete walls of the biological shield and containment structure, in conjunction with the distance to the nearest residence. There are no plans to change this mode of operation or to permanently store spent irradiated fuel on the MNRC site during the period of the license renewal term. As a result, there is no environmental impact due to storage of spent fuel at MNRC.

Minor amounts of solid radioactive waste are generated by reactor maintenance activities and by the performing of experiments. Chapter 11 of the SAR summarizes the sources of solid waste produced by MNRC.

Normally, solid radioactive waste is shipped to an authorized solid waste broker or brokerage service. The amount of radioactive waste generated at MNRC is very modest and only a single "B-25 box" shipment is needed every 5 years to prevent the long term accumulation of radioactive material. The majority of this waste is in the form of spent demineralizer resin, primary water filters, activated metal sample encapsulations, and contaminated PPE. The individual responsible for making the waste shipment must have documented training that meets the requirements of Title 49, Chapter I of the Code of Federal Regulations, Part 172, Subpart H.

All shipments are conducted in accordance with NRC/DOT regulations and all material is shipped to disposal sites that are licensed and that comply with NRC or Agreement State regulations. No changes in waste management procedures or operations are expected during the license renewal term. Therefore, there is no impact on the environment due to storage and shipment of radiological waste by MNRC during the license renewal term.

4.1.22 Environmental Justice

Environmental justice refers to a Federal policy under which Federal action (such as the renewal of the MNRC license by the NRC) should not result in disproportionally high and adverse environmental impacts on low-income or minority populations.

Because the continued operation (license renewal) of the MNRC will not produce a significant impact then there can be no disproportionately high and adverse effect or impacts on any member of the public. As outlined elsewhere in this report, the MNRC is situated on 2.4 acre lot located on the former McClellan Air Force Base. The majority of the buildings in the surrounding area are either vacant or dedicated to light industry. The largest potential concern for the public would be radiation exposure to the public due to the continued operation of the MNRC. As outlined previously in this report routine operations of the facility result in doses (from direct radiation and Ar-41 effluence) that are well below the applicable 10 CFR 20 limits for the maximum exposed individual. Furthermore the maximum hypothetical accident is not capable of generating doses beyond the 10 CFR 20 annual limits for general members of the public.

4.2 Assessment of NUREG-1437 Category 1 Issues

4.2.1 Surface Water Quality, Hydrology and Use

The MNRC reactor is cooled by a secondary cooling water system that uses a mechanical draft cooling tower to remove heat from the reactor. The only water that is continuously discharged is due to evaporative losses while the cooling tower is actively operating to cool the reactor. Makeup water is obtained from the local sanitary water provider, Sacramento Suburban. The total maximum water usage by the facility is 20 GPM. This level of usage is only possible if the facility were to operate at its maximum power level 24 hours a day 7 days a week. Typical average annual usage is closer to 3 GPM and is insignificant relative to the surrounding population's water usage and places essentially no burden on the local wastewater treatment system.

Surface rainwater runoff from MNRC is relatively small compared to the surface runoff from the surrounding McClellan Business Park. Runoff from MNRC is directed to the storm drainage system along with runoff from the rest of the McClellan Business Park. The present or continued operation of MNRC has no impact on surface water quality, hydrology, or use. The issues related to this topic for commercial power plants are not applicable to MNRC due to the facility's small size and low water usage.

4.2.2 Aquatic Ecology

MNRC does not obtain water from, or discharge water to, a body of surface water. All water used at the facility is from the local sanitary water supplier. The volume of water used by the facility is a very small percentage of the total volume of water used by the surrounding area. All water discharged by the facility is released either to the atmosphere by evaporative losses at the cooling tower or to the sanitary sewer system.

Biocides are used in the secondary cooling water to eliminate or limit the growth of nuisance microbiological organisms (primarily algae) in the cooling tower. The measures used at MNRC to control the growth of nuisance microbiological organisms in the cooling tower are comparable to those used at large office buildings and industrial complexes that have cooling towers. The volume of liquid effluent released to the sanitary sewer system represents a negligible percentage of the total volume of wastewater treated by the sewage treatment plant.

A descaler is also added to the secondary coolant to prevent blockage in the primary to secondary heat exchanger. The scope and consequences of this practice is similar to the use of biocides to control algae growth described above.

Because no water is obtained from a body of surface water, there is no possibility of entrainment or entrapment of plankton, fish, shellfish, or other organisms. Also, because no water containing chemical or radioactive contaminates is directly discharged to a body of surface water, there is no impact on aquatic ecology due to heat, cold, contaminants, gas supersaturation, or low dissolved oxygen resulting from the discharge. As such, there is no impact on the aquatic ecology associated with the present or continued operation of MNRC. The issues related to this topic are not applicable to MNRC.

4.2.3 Ground Water Use and Quality

MNRC uses a mechanical draft cooling tower to remove heat from the secondary coolant system. This tower dissipates heat to the atmosphere along with small quantities of water (maximum of 15 gpm). The cooling mechanism is the largest user of water at the MNRC.

The MNRC is requesting to be licensed to operate at 1.0 MW 24 hours a day 7 days a week. Even under these conditions the MNRC would use approximately 13 gpm total (8 gpm reactor cooling and 5 gpm for all other uses). As the MNRC typically operates at 1 MW for only one shift, a more realistic water consumption is 13 gpm for 25 to 35 hours per week. This places the actually average yearly consumption around 3 gpm. Sacramento Suburban Water District can produce just over 93,000 gpm from groundwater sources.

In an emergency situation the MNRC could require an additional 20 GPM for 3.7 hours to cool the reactor core. The MNRC maintains a supply of water onsite for such an emergency and only relies on domestic water if this onsite water was to somehow become unavailable. Even if domestic water was need for emergency core cooling it represents an insignificant fraction of the local water provider’s capacity.

In addition, there are no major refurbishment or modification activities anticipated as a result of the license renewal. The only modification or refurbishment activities planned by MNRC during the license renewal term are simple upgrades to enhance the facility's capability to conduct research and radiography. None of these upgrades will require significant amounts of water during their installation and none will have any substantial impact on the amount of water used by the facility on a daily basis. Therefore, the present and continued operation of MNRC has no impact on groundwater use or quality.

4.2.4 Terrestrial Resources

MNRC plans no refurbishment activities associated with the license renewal effort. Therefore, no additional land will be disturbed and there will be no impact on plant or animal habitats caused by construction activities. MNRC does not generate power and has no power lines maintained by the facility. The power lines that do provide power to the MNRC are located underground and cannot adversely affect local wildlife.

There is no impact on terrestrial resources caused by the use of a cooling pond because MNRC does not have a cooling pond. MNRC uses a mechanical draft cooling tower to remove heat from the secondary coolant system. This cooling tower releases approximately 8 gpm of water into the atmosphere when it is operating. This amount of water represents a negligible increase in the amount of water evaporated into the air from other terrestrial sources. There have been no adverse impacts on any terrestrial resources observed as a result of the operation of this cooling tower. The cooling tower is similar in size and capacity to cooling towers used at various industrial facilities and large office buildings.

Therefore, the present or continued operation of MNRC has no impact on terrestrial resources, including native flora and fauna or domesticated animals or managed crops. Issues associated with power lines and cooling ponds are not applicable and issues related to operation of the cooling tower are not a concern due to its relatively small size.

4.2.5 Threatened or Endangered Species

The present or continued operation of MNRC has no impact on any threatened or endangered species as described in Section 4.1.10. No major refurbishment activities associated with the license renewal effort or during the license renewal term are planned that would potentially disturb the environment of any threatened or endangered species.

4.2.6 Land Use

MNRC does not generate electricity and does not own any transmission lines. Transmission lines that provide power to the facility are located underground. Thus, there is no impact on land use due to transmission line right-of-ways related to present or continued operation of MNRC.

All land used by MNRC is contained with the 2.4 acre plot of land the reactor building is situated on. No additional land, either within the McClellan Business Park or on any other property, will be used by MNRC during the license renewal term. No major modifications or refurbishment activities are anticipated that will require additional land use. Thus, continued operation of MNRC has no impact on on-site land use.

4.2.7 Air Quality

MNRC does not produce electricity and does not maintain any transmission lines. Power lines that supply power to the facility are located underground. Therefore, impacts on air quality due to the effects of transmission lines are not applicable to operation of MNRC.

In addition, no major refurbishment activities associated with the license renewal effort are planned. Any modifications performed during the license renewal term will be minor in scope. These modifications will be performed by the existing staff; possibly supplemented by a small number of temporary contractors. The work force required to operate the facility and perform modifications represents a negligible percentage of the total number of people employed within the greater Sacramento area. There will be no impact on the environment due to vehicle exhaust or other construction activities associated with these minor modifications. Thus, the continued operation of MNRC has no impact on air quality. The minor amount of Ar-41 effluence released from MNRC operations is discussed elsewhere in this document.

4.2.8 Human Health

There are no major refurbishments activities planned that are associated with the license renewal of MNRC. The only modifications that are anticipated during the license renewal term are minor upgrades that are associated with facility maintenance activities. Thus, there is no impact on human health due to refurbishment associated with the license renewal. MNRC does not generate or transmit electricity. Therefore, there is no impact on human health due to acute or chronic effects of electromagnetic fields.

MNRC does not directly discharge water to a body of surface water. Therefore, the operation of MNRC does not promote or stimulate the growth of any microbiological organisms. Normal industrial health and hygienic practices will ensure that there is no occupational health issues related to limit microbiological growth that occurs at the cooling tower.

In addition, the license renewal of MNRC will not impact human health with respect radiation exposure. The facility is operated (and has been operated for ~30 years) in a manner that maintains radioactive releases at a minimum and well below the limits prescribed by law. The ventilation system at MNRC is designed to that there are no unmonitored gaseous effluent releases to the atmosphere. MNRC's ventilation system is designed to perform the following radiological control functions:

- Maintain the reactor room at a slightly negative pressure with respect to the surrounding environment and rooms to minimize the spread of radioactive contamination.
- Ensure that maximum dilution of potentially contaminated air is attained; resulting in minimum concentrations of radioactive gases being released to the environment.
- Prevent uncontrolled release of radioactive materials to the environment in the event of an accident (e.g. fuel failure).
- Ensure that all airborne radioactive material that is released from building is directed up the stack which is monitored via a continuously air monitoring system.

During normal facility operation, air from all 4 radiography bays, the staging areas, the equipment room, and the reactor room is drawn into and exhausted out of the MNRC 60 foot stack. Due to the negative relative pressure maintained inside the reactor room, there are no other release points. The air is monitored prior to release to ensure that there is no possibility of exceeding established limits. In the event of an emergency, the reactor room ventilation system can be isolated so that contaminated air is circulated through a HEPA and activated charcoal filters.

Under normal conditions only Ar-41 is released to the public via the stack. The concentration of Ar-41 released to the public is well under the 10 CFR 20 appendix B values. As such the corresponding dose to the maximum exposed individual is well under the 10 CFR 20 limits for general members of the public.

MNRC has evaluated historical occupational doses received by MNRC personnel and has determined that these doses are well below the limits established by 10 CFR 20, Subpart C and that they are "as low as reasonably achievable." No changes in reactor operation are planned for the license renewal term that would increase these occupational doses.

In addition, MNRC has calculated the total dose received by the facility staff as well as the general public as a result of the Maximum Hypothetical Accident (MHA). The MHA is a bounding accident that envelops all design basis accidents that are postulated to occur at the facility. The accepted MHA for TRIGA reactors is a single element failure in air after the reactor has been operated at maximum power for a long period of time. The results of the calculations are well below the limits specified in the Code of Federal Regulations for both facility staff and the general public. Results of the analysis of the radiological consequences resulting from the MHA are presented in Chapter 13 of the SAR.

The reactor is located 4 feet below grade level and is completely enclosed by a reinforced concrete structure. The design of the facility's shielding prevents direct radiation exposure to members of the general public. Some scattered radiation from the operation of the radiography bays does reach the MNRC fence line. These dose rates are very low and do not result in exceeded the applicable 10 CFR 20 limits for the maximum exposed individuals (standing at the MNRC fence line all year). These doses are described in more detail in chapter 11 of the SAR. All potentially contaminated air released from the facility is monitored to ensure that the concentrations of radioactive material released is maintained within regulatory limits. Given the extremely small amounts of gaseous effluent radioactive material that is released, there is no significant impact on public health due to the continued operation of MMRC.

4.2.9 Socioeconomics

The MNRC is a small research reactor located on the outskirts of a major metropolitan area. Staff size is just under 10 full time employees and is not expected to increase significantly during the term of the license renewal. Given the large population of the greater Sacramento area there is no impact on housing, transportation, education, public utilities, social services, or land use due to changes in the tax base.

With regard to aesthetics, MNRC is a small facility whose design is compatible with other structures located in the McClellan Business Park. The reactor building is less than 50 feet tall with the exception of the exhaust stack; the top of which is 60 feet above grade level. No changes in appearance will be made during the license renewal term. In addition, MNRC does not generate electricity and thus does not maintain any power transmission lines. Therefore, the continued operation of MNRC has no impact on the aesthetics of the surrounding area.

No refurbishment activities except for minor upgrades related to facility maintenance will be performed during the license renewal term. To reiterate, the facility is very small and employs only a relatively small number of personnel as compared to the total number of people that reside or work in the surrounding area. Therefore, the continued operation of MNRC has no impact on the socioeconomics of the greater Sacramento Area.

4.2.10 Postulated Accidents

There are no nearby industrial, transportation, or military facilities with the potential of causing a credible accident that would result in a release of radioactive material from UCD/MNRC that would exceed the general public exposure limits of 10 CFR Part 20.

The basic UCD/MNRC design and structure provide significant protection for the reactor. As described in Chapter 1, the reactor core is below grade and surrounded by a monolithic block of reinforced concrete from six to nine feet thick. Also, the above grade structures of the facility that surround the reactor tank are constructed of reinforced concrete and reinforced concrete block.

The accident, from sources outside the UCD/MNRC that is worthy of further discussion is one involving an aircraft since the facility is located near an airstrip. The possibility of an aircraft impact involving the UCD/MNRC reactor has been evaluated (assuming airstrip operation numbers from the early 80's as they are more conservative that current values), see Chapter 13, and it has been determined that the probability of such an event occurring is less than 10^{-8} per year. Therefore, this type of accident is considered non-credible.

The UCD/MNRC reactor fuel, control-rod drives, control rods, and experimental systems are similar to many other systems used throughout the United States. These items have well-established operating experience and no new significant reactor-design activity was required.

The UCD/MNRC facility has been specially designed to accommodate the reactor. The tank is embedded in a massive reinforced-concrete block, which is, in turn, surrounded by the reinforced concrete walls and roofs of the radiography bays. The core is approximately 4.5 ft below ground level. The reactor shielding configuration is similar to other TRIGA® reactors. The reactor bulk shielding and the radiography bay walls and reinforced roofs provide biological shielding to keep personnel exposures as low as reasonably achievable, and protects the reactor from natural phenomena. The reactor room air handling system maintains the reactor room at a negative pressure with respect to surrounding areas to control and prevent the spread of airborne radioactive materials. The air from the reactor room passes through a HEPA filter prior to being discharged to the atmosphere. In the event of a release of radioactive material within the reactor room, the reactor room air handling system automatically isolates the room preventing the release of activity to the atmosphere. The room air can then be recirculated within the reactor room and through the HEPA and charcoal filters to remove particulates.

The reactor operates at a nominal steady-state power of 1 MW. The average power density is approximately 10 kW/element, whereas the same fuel has successfully operated at other facilities with power densities in excess of 30 kW/element. The reactor is also equipped with a pulsing capability. This is the same type of pulsing operation that has been successfully demonstrated with many other TRIGA®-type reactors.

The inherent safety of the reactor lies primarily in the large, prompt negative temperature coefficient of reactivity characteristic of the TRIGA® fuel-moderator material. Thus, even when large sudden insertions of reactivity are made and the reactor power rises on a short period, the prompt negative reactivity feedback produced by an increase in temperature causes the power excursion to be terminated before the fuel temperature approaches its safety limit. The prompt shutdown and safety characteristics of reactors fueled with TRIGA® fuel have been demonstrated during transient tests conducted at GA in La Jolla, California as well as other facilities. This demonstrated safety has permitted the location of TRIGA® fueled reactors in urban areas in buildings without the pressure-type containment usually required for power reactors. Chapters 4 and 13 of the SAR discuss this characteristic in detail.

Abnormal conditions or postulated accidents discussed in this report (See Chapter 13) include:

(a) Maximum Hypothetical Accident (MHA);

(b) Reactivity insertion;

(c) Loss of coolant;

(d) Loss of heat-removal system;

(e) Fuel cladding failure;

(f) Aircraft crashes;

(g) Pyrotechnic detonation.

In the first three postulated accidents, fuel and cladding temperatures remain at levels below those sufficient to produce cladding failure, and thus, no release of fission products would occur.

The limiting fault condition (i.e., the Maximum Hypothetical Accident (MHA), which assumes failure of fuel clad and an air release of fission products from one fuel element, will result in radiation doses to operations and base personnel and the general public for both thyroid and whole body that is orders of magnitude of those of ANS 15.7 (see Section 2.1.2 for boundary definitions). Chapter 13 of the SAR contains a detailed discussion of this accident scenario.

The calculations of the probability of an airplane impacting the facility and damaging the reactor have been analyzed. It has been found that the probability of such an accident is less than 10^{-8}/year and is, therefore, considered non-credible. The aircraft impact accident analysis is summarized in Chapter 13 of the SAR. The complete bounding probabilistic assessment of an aircraft impact risk at the former McClellan AFB is contained in Appendix C of the SAR.

The amount of explosive material allowed in the radiological bays at any given time will be limited to prevent damage to the reactor (Chapters 10 and 13 of the SAR).

The effects of a single fuel element clad failure in air have been evaluated for both operations personnel and the general public. The results show exposures below the 10 CFR Part 20 limits, see Chapter 13 and Appendix B of the SAR for the analysis.

Radiation-monitoring equipment has been installed at key locations to monitor radiation levels and to sound alarms if preset values are exceeded. Also, a system of reactor scrams, interlocks and administrative controls have been provided to prevent operating personnel from entering high radiation areas, namely the radiography bays. Included in the reactor scram chains are a number of ripcords in the radiography bays. These rip cords allow personnel in the radiography bays to terminate reactor operations if radiation levels become abnormally high.

4.2.11 Decommissioning

Ideally MNRC does not store radioactive material or fuel on a permanent basis. MNRC is forced to store spent fuel until the moratorium on DOE accepting spent TRIGA fuel is lifted. MNRC may not be decommissioned until all spent fuel is removed from the facility. However given the low power nature of the reactor the facilities fuel usage and spent fuel production is very low (~2 spent elements per year). Therefore any amount of additional solid or liquid waste, gaseous effluence, or spent fuel that would be store onsite as a result of the continued operation of MNRC would be insignificant. Thus, there would be no more than an insignificant amount of radioactive waste generated during decommissioning after an additional 20 years than would be generated if the facility were decommissioned at the end of the current license term.

Doses to the public will continue to be well below 10 CFR 20 limits during the license renewal term because no changes to operation of the facility are anticipated. Occupational doses will increase only an insignificant amount due to buildup of long-lived radionuclides within the facility.

Due to the small size of the facility, a significant amount of construction activity will not be required to complete the decommissioning. Therefore, there will be no impact on air quality or water quality during decommissioning either at the end of the current license period or at the end of the license renewal term. Because no additional land will be disturbed and no materials will be released to the atmosphere or to a body of surface water, there are no ecological impacts associated with decommissioning either at the end of the current license period or at the end of the license renewal term.

Also, because of its small size, decommissioning the facility would have little or no socioeconomic impacts. The increased work force required to complete the decommissioning would be an insignificant increase in the population in the area. Any impacts that did occur would be the same at the end of the license renewal term as at the end of the current license period.

4.2.12 Uranium Fuel Cycle and Waste Management

4.2.12.1 Nuclear Fuel

The fuel handling cycle consists of: 1) receiving new (i.e., unirradiated) fuel elements, 2) transferring the new fuel elements to an approved fuel storage location, 3) unloading irradiated fuel elements from the reactor into the in-pool storage locations 4) transferring the new fuel elements from an approved storage location to the reactor, and 5) transferring the spent fuel elements from the in-pool storage locations to the fuel pits or fuel transfer cask for shipment.

New fuel is obtained from the DOE and arrives at the facility in DOT approved shipping containers. The new fuel is removed from the shipping containers by hand and placed in an approved storage location. All approved fuel storage locations are designed so that k_{eff} is maintained at less than 0.90 for all conditions. All new fuel elements are inspected before being placed in the reactor. The reactor supervisor ensures that a complete and accurate fuel inventory is maintained. Prior to being irradiated, new fuel is not radioactive and can be handled without risk.

During all irradiated fuel handling activities, water in the reactor pool is maintained at a level to provide maximum shielding for the operators. Spent fuel is transferred using a General Atomics built fuel transfer cask. All spent fuel transfers into the cask are made underwater inside the reactor tank. These operations result in essentially no dose to the reactor operators performing the fuel movements.

The DOE maintains title to all nuclear fuel used at MNRC and is obligated by contract to take possession of the fuel for storage and/or reprocessing after its use in the reactor. Irradiated fuel does not leave the reactor pool or fuel pit until it is loaded into an NRC/DOT approved cask for shipment. Transfer of spent fuel from in-tank storage locations to the cask is performed manually; with the cask underwater. The 5-ton capacity overhead crane is used to lower and remove the cask from the reactor tank. The cask is decontaminated prior to release for shipment.

A spent fuel element is not loaded into a shipping cask until a predetermined cooling period has elapsed since the element was last removed from the reactor core. Cooling times are based on a thermal analysis of the decay heat generated by a spent fuel element and by the storage requirements established by the DOE. Typically, this cool down period is only a few days to weeks which is significantly shorter than commercial spent fuel.

No changes in this process are anticipated during the license renewal term. No irradiated spent fuel will be permanently stored at MNRC either in the reactor tank or in the fuel pits.

4.2.12.2 Radioactive Material & Waste

At the MNRC, radioactive waste is generally considered to be any item or substance which is no longer of use to the facility and which contains, or is suspected of containing, radioactivity above the established natural background radioactivity. Because MNRC waste volumes are small and the nature of the waste items is limited and reasonably repetitive, there is usually little question about what is or is not radioactive waste. Equipment and components are categorized as waste by the reactor operations staff, while standard consumable supplies like plastic bags, gloves, absorbent material, disposable lab coats, etc., automatically become radioactive waste if detectable radioactivity above background is found to be present.

When possible, radioactive waste is initially segregated at the point of origin from items that will not be considered waste. Screening is based on the presence of detectable radioactivity using appropriate monitoring and detection techniques and on the projected future need for the items and materials involved. All items and materials initially categorized as radioactive waste are monitored a second time before packaging for disposal to confirm data needed for waste records, and to provide a final opportunity for decontamination/reclamation of an item. This helps reduce the volume of radioactive waste by eliminating disposal of items that can still be used.

<u>Solid Waste</u>

The procedures for managing solid waste are specified in Chapter 11 of the SAR. As with most non-power reactors, solid waste is generated from reactor maintenance operations and irradiations of various experiments. A general idea of where solid waste enters the waste control program can be obtained from the preceding information. No solid radioactive waste is intended to be retained or permanently stored on site.

Appropriate radiation monitoring instrumentation will be used for identifying and segregating solid radioactive waste. Radioactive waste is packaged in metal drums or boxes within the restricted area of the MNRC and is temporarily stored in a weatherproof enclosure within the MNRC site boundary until shipment for disposal or transfer to a waste broker. Typically a single routine “B-25 box” shipment is made every 5 years. The facility generates little to no mixed waste.

As stated previously, minimization of radioactive waste is a policy of the MNRC. Although there are no numerical volume goals set due to the small volume of waste generated at the MNRC, the health physics supervisor and the reactor operations supervisor periodically assess operations for the purpose of identifying opportunities or new technologies that will reduce or eliminate the generation of radioactive waste. The Nuclear Safety Committee (NSC) also conducts an annual audit of the waste minimization programs as described chapter 11 of the SAR.

<u>Liquid Waste</u>

It is MNRC policy to minimize the release of radioactive liquid waste. Because normal MNRC operations create only small volumes of liquid which contain radioactivity, it has been possible to convert the liquids to a solid waste form and thus adhere to facility policy. In special cases, the MNRC may generate a large volume of radioactive liquid waste which cannot be converted to a solid waste. In these cases, disposal by the sanitary sewer in accordance with 10 CFR 20 may be required. This disposal can only be authorized by the MNRC Director.

Chapter 11 in the SAR describes the liquid radioactive sources associated with the MNRC reactor program. As indicated in chapter 11 of the SAR, the reactor primary coolant is the only significant source. Since the primary coolant is by design contained to the maximum extent possible, there are no routine releases of this liquid and thus no significant volumes of liquid which require management as liquid waste. Certain maintenance operations, such as replacement of demineralizer resin bottles, result in very small amounts of primary coolant being drained from the water purification loop, but this liquid is easily collected at the point of origin and converted into an approved solid waste form. Other liquid radioactive waste sources such as laboratory wastes, decontamination solutions, and liquid spills have been very rare and easily within the capability of the health physics staff to convert to a solid.

Certain maintenance operations may generate a large volume of liquid waste, e.g., heat exchanger cleaning or activated concrete removal. In these cases, sewer disposal in accordance with 10 CFR 20 may be the only viable option for disposal. These cases are rare and still are not considered the norm.

Gaseous Effluent

Although Ar-41 is released from the MNRC stack in the facility ventilation exhaust, this release is not considered to be waste in the same sense as the solid waste which is collected and disposed of by the facility. The Ar-41 is usually classified as an effluent which is a routine part of the normal operation of the MNRC reactor. In the MNRC facility, as in many non-power reactors, there are no special off-gas collection systems for the Ar-41. Typically, this gas simply mixes with reactor room and other facility air and is discharged along with the normal ventilation exhaust.

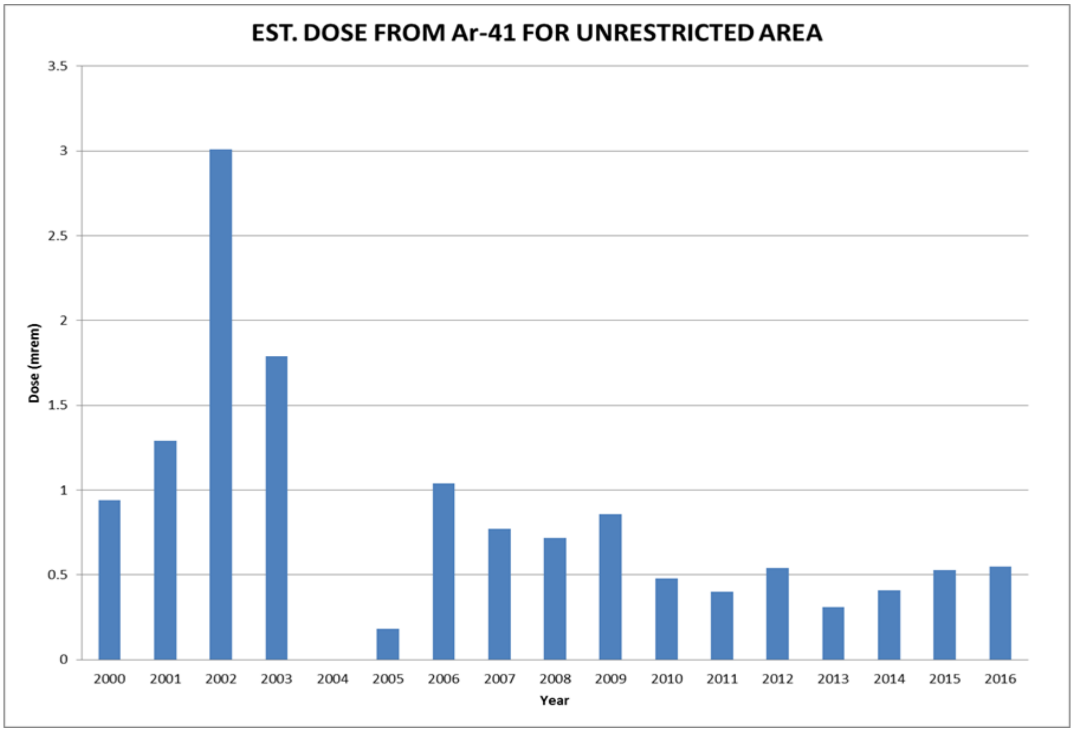

Figure 20 Off-Site Maximum Exposed Individual Dose from Ar-41 Effluence

(note data from 2004 is missing)

All doses in unrestricted areas from Ar-41 effluences, as seen in figure 20, are below the 10 CFR 20 limits. Just as with radiation worker doses a decrease in unrestricted area doses can be seen in 2006 and again in 2010. This can be explained by the fact that the facility moved to single-shift operation in 2006 and rarely operated above 1.0 MW after 2009. These doses are for the maximum exposed individual standing at the highest dose rate position caused by Ar-41 effluence for the entire year. The EPA CAP88 model provides a much more realistic estimation of public dose from radioactive effluence. These CAP88 values are significantly lower than the values given in figure 20.

4.2.12.3 Offsite Radiological Impacts Not Associated with Spent Fuel

The only gaseous waste released to the public is Ar-41 as routine effluence as described in section 4.2.12.2. All effluence is monitored and released up the MNRC's stack. The Ar-41 released is well below the 10 CFR 20 limits. It is MNRC policy to not dispose of liquid waste (even when legally permitted) down the sanitary sewer.

The radiation levels of any waste produced by MNRC and released to the environment are well below established limits, there is no significant impact on the environment. In addition, the maximum dose received by any one individual living in proximity to the site has been determined to be well below the limits established in 10 CFR 20.1101(d) in the SAR.

4.2.12.4 Offsite Radiological Impacts of Spent Fuel Disposal

The reactor core at MNRC is comprised of approximately 100 fuel rods enriched to less than 20% U-235. Each fuel element is approximately 1.5 inches in diameter and 15 inches in length (active fuel). The relatively low power level of the fuel and modest utilization of the fuel results in a very small average annual production of spent fuel (~2 elements).

The DOE supplies fuel to the MNRC. The DOE retains title of the fuel and is obligated to take possession once it can no longer be used in the reactor. Normally the fuel is kept inside the tank, but away from the core, so that it may cool sufficiently. Once enough spent fuel is ready to justify a shipment, an approved DOE subcontractor uses a DOT approved transportation cask to move the spent fuel from MNRC to Idaho National Laboratory. The shipping container is a certified "Type B" container. In order to be certified the container must pass a number of rigorous tests to simulate serious accidents while in transit. No radioactive material has ever been released from a type B container while in transit. Therefore, the radiological impact of spent fuel disposal is not significant.

4.2.12.5 Non-Radiological Waste

Non-radioactive waste at MNRC is relatively small as the facility has no wet chemistry laboratories. The chemical operations at MNRC are closer in scope to that of a machine shop. Universal waste (batteries and fluorescent lights) are disposed of at a local licensed waste disposal facility. Oily rags are accumulated and disposed of in accordance with local and state regulations. All other non-radioactive waste is disposed of by the main UC Davis safety services. Mixed waste is not generated at MNRC. MNRC is permitted to produce and accumulate waste via a permit granted by the County of Sacramento.

The secondary system water quality is maintained using 3 commercial products using containing hazardous materials. These products are the same or similar to those used in the air conditioning cooling towers of industrial facilities or large office buildings. These chemicals are bromine (30 gallons/year), a biocide (15 gallons/year), and a descaler (30 gallons/year). These materials are stored and used in accordance with all local state, and federal regulations.

5.0 New and Significant Information

During the preparation of this request for license renewal, the information contained in the SAR has been reviewed and updated to reflect any changes to the facility. As part of the preparation of the ER, the information in the SAR was reviewed to determine if any new or significant information that might have an adverse impact on the environment had been discovered.

During this review, MNRC has not discovered any new and significant information that would cause a change in the environmental impact if operation of the facility were to continue for the license renewal term. It is likely the insignificant environmental impact predicted 20 years ago when the license was issued, is even less today. This is due to the decreased facility utilization (i.e. multiple shift operation vs. single shift operation.

The projected increases in population in region immediately around the MNRC and the greater Sacramento Area will not result in a significant increase in dose to the public as the Ar-41 released from the facility is very minimal and there are no residential buildings within several 1000 feet of the facility. Increases in highway and decreases air traffic in the vicinity of the facility do not fundamentally change the assessments documented in the SAR.

The projected increases in student body size at the UC Davis will have no direct effect because the University is located 10 miles (Medical Center) and 26 miles (main campus) away from the MNRC. The expected increase in population around the facility is small and will not adversely impact the time or effort required to evacuate the area around the facility in the event of a radiological emergency.

There are no major refurbishment activities or modifications planned that are associated with the license renewal that will have any impact on conduct of operations of the facility. There will be little or no significant increase in levels of radiation or radioactive waste generated during normal facility operation or during severe accidents. There will be no change in water use or in the release of gaseous or liquid effluents to the environment.

Therefore, the MNRC staff is not aware of any new or significant information that would cause the operation of the facility during the license renewal term to have any adverse impact on the environment.

5.1 Status of Compliance

The MNRC is home to a 2.0 MW (requesting to be relicensed at 1.0 MW) TRIGA mark II nuclear reactor. The MNRC is owned and operated by the University of California at Davis. The regulatory framework under which the MNRC is operated is complicated. This section outlines the regulatory authorities, primary regulatory codes, compliance documents, auditing structure, and responsibilities.

United States Nuclear Regulatory Commission (NRC) grants the MNRC permission to operate the reactor under license number R-130. All legal responsibilities and obligations are outlined under title 10 of the Federal Code of Regulations. The MNRC is audited 2 times per year by an NRC inspector to ensure compliance with the regulations. An additional annual audit is performed by the MNRC Nuclear Safety Committee. The primary compliance documents are the R-130 license and the MNRC technical specifications.

State of California does not license the MNRC for any activities. However, the MNRC is responsible to comply with all CAL OSHA requirements under the California Code of Regulations Title 8. This document, the campus laboratory safety manual, and the MNRC Explosives Safety Manual are written to meet the Title 8 requirements. Annual internal safety audits and annual UC Davis ES&H safety audits are performed.

Sacramento County is the implementing government body for the California Environmental Protection Agency. The MNRC is licensed by the Sacramento County Environmental Management Department as a hazardous waste generator. The MNRC must register as a hazardous waste generator annually in order to be relicensed. A formal audit is conducted once every three years as part of maintaining this license.

United States Department of Transportation regulates all dangerous goods shipments under tile 49 of the Federal Code of Regulations. All dangerous goods shippers shall possess current dangerous goods shipping training if they are to ship dangerous goods. The MNRC is not audited regularly by the USDOT or the USFAA. The shipping records for dangerous goods are typically reviewed by the NRC.

United States Department of Justice Bureau of Alcohol, Tabacco, Firearms, and Explosives has given the MNRC an exemption so that a federal license and permit are not required to possess explosive material. The MNRC must still follow the explosive material requirement of title 27 Code of Federal Regulations Part 555. These requirements are implemented in the MNRC Explosives Safety Site Plan.

The United States Department of Energy (DOE) owns all of the nuclear fuel at MNRC. The DOE is responsible for shipment of spent fuel as well as its final disposal. The MNRC is responsible for providing the DOE, the National Nuclear Safety Agency (NNSA), and the NRC with an annual inventory of the fuel.

University of California at Davis sets forth a number of programmatic requirements in order to comply CAL OSHA requirements. In some instances the campus implements requirements more restrictive than those outlined in Title 8. As the MNRC is licensed by the NRC, the MNRC is not regulated under the California Code of Regulations Title 17.

6.0 Summary of License Renewal Impacts

The environmental impact of continued operation of MNRC for the period of the license renewal term has been assessed as described in Section 4.0. The potential for environmental impact has been assessed with respect to all 92 issues listed in Appendix B of Subpart A of 10 CFR 51. In addition, research has been conducted as described in Section 5.0 to determine if there is any new and significant information available that would change the result of any previous analysis of the impact of continued operation.

Based on the reviews and assessments performed, the MNRC staff has determined that the continued operation of the facility for the license renewal term has no adverse impact on the environment. Decommissioning the facility at the end of the license renewal term will not have any greater impact than decommissioning at the end of the current license term because there is no permanent storage of spent fuel or other radioactive waste at the facility. Furthermore, there are no major refurbishment activities required as part of the license renewal effort or during the license renewal term that could adversely impact the environment. If unforeseen activities that could adversely impact the environment during the license renewal term were to be carried out, a separate license amendment and environmental report would need to be submitted to the NRC describing those activities prior to their implementation.

No mitigating actions of any kind other than those controls, practices, and procedures that are already in place are required to lessen or eliminate any potential impact on the environment. No additional structures, systems or components are required to provide additional protection to the environment.

7.0 Alternatives to License Renewal

MNRC's operating license will expire on August 18, 2018. This Environmental Report has been prepared to support a request for an extension of the operating license for an additional 20 years. That is, MNRC is requesting an extension of the operating license until August 18, 2038. Therefore, there are two options applicable to the renewal of the facility's operating license for the requested 20-year period:

1. No license renewal. Under this "no action" alternative, the facility would cease to operate on August 18**,** 2018. Due to the fact DOE cannot accept spent TRIGA fuel the MNRC could not began decommissioning until a later date. It is unknown when all spent fuel could be transferred back to DOE. It is likely the MNRC would have to remain in a “possession only” status meaning the facility may possess fuel but may not allow the reactor to go critical. This period of possession only would likely extend well into the 2020s.

2. A renewal is granted until August 18, 2038 in response to the renewal application request filed by UC Davis along with this environmental report. A denial or no action occurs on the request for a 20-year extension to the operating license is another possibility. The environmental impact of each of these options is discussed in the following sections. It is assumed that the facility would be decommissioned after expiration of the operating license under both options if fuel can be returned to DOE. However, an extension of the operating license until August 18 2038, has no environmental impact with respect to decommissioning, other than determining when those activities will commence.

7.1 No License Extension Granted (No Action Alternative)

There are currently two dozen operating research and training reactors in the United States. This represents a >50% decline since 1980 in the number of operating research reactors. United States Senate Bill (S. 242, "Department of Energy University Nuclear Science and Engineering Act") describes the decline in the number of University Research Reactors as a threat to the health of people in the United States and to national security.

The MNRC is the largest research reactor in the western half of the United States. MNRC is one of three research reactors in the United States providing commercial neutron radiography services. These services are of vital importance to the aerospace industry. Of these three reactors providing commercial neutron radiography services MNRC is one of only two that provides these services on energetic devices. These services are vital to a number of large defense contractors that support national security and national defense. Furthermore, neutron radiography may play an important role in the non-destructive testing in the emerging field of metal additive manufacturing. It is unlikely other existing research reactors could be modified to fulfill this role if MNRC’s license was not renewed.

MNRC also provides high school outreach, college level class work, and irradiation services in support of Lawrence Livermore, Los Alamos, and Lawrence Berkeley National Laboratories. If the MNRC license is not renewed, the mission of certain programs within these laboratories will be at least partially compromised.

MNRC's educational and outreach programs also provide some relief in the human capital crisis in the nuclear power industry. Though the strength of the "nuclear renaissance" is less vigorous than anticipated, the need for large carbon free baseline power will undoubtedly drive the future expansion of nuclear power in the United States. The nuclear power industry will continue to rely on facilities such as MNRC to provide students with hands-on experience during their higher education.

The MNRC has no significant environmental impact during its operation. The decommissioning of the facility will have a slightly higher environmental impact (though still not necessarily a significant impact) due to the scope of the decommissioning. The decommissioning of the MNRC is inevitable. However, there is no gain (from an environmental standpoint) if the facility is decommissioned now or at the end of the proposed license renewal in 2038.

7.2 License Extension Granted to August 18th 2038

Under this alternative, the MNRC would continue to operate until August 18th, 2038. During these 20 years from August 2018 to August 2038, MNRC would continue to conduct operations as described in the SAR (primarily education and neutron radiography) and would continue to use the existing procedures, practices, systems and components. Impacts to the environment during this period would be similar to those incurred with the proposed twenty-year renewal period just discussed in this report.

8.0 Evaluation of Environmental Impact Against Alternative Actions

As described in Section 4.0, there is no significant environmental impact related to the continued operation of MNRC for the license renewal term. No major refurbishment activities or mitigating actions are required to support the license renewal effort and no major modifications to facility operations or procedures are planned. The only modifications anticipated are minor upgrades related to facility maintenance activities. Because no spent fuel is permanently stored at MNRC and all high and low level waste is shipped off-site for disposal, the extended period of operation will have minimal impacts on the decontamination and decommissioning (D&D) of the facility. There is no significant environmental impact during the extended period of operation.

If the facility license is not extended and shutdown is required, there would be a significant impact related to the loss of the training/education opportunities and neutron radiography services.

Furthermore, the non-renewal of the MNRC license will not immediately translate into decommissioning the facility as spent fuel cannot be return to the DOE at this time. If MNRC were to terminate operation it is unknown when fuel could be returned to DOE and decommissioning could begin. The non-significant environmental impact of operating the facility is essentially the same as not operating the facility for a multi-year period waiting for the fuel to be returned to DOE.

The decommissioning effort would cause a slight increase in the impact of the facility in the short term. After completion of the decommissioning, there would be a slight decrease in the impact of the facility on the environment. However, this slight decrease is not significant as described in section 4. The changes would be approximately the same whether the decommissioning occurred at the end of the current license term or at a future date.

9.0 References

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