



2018

ANNUAL REPORT

Docket Number 50-607

License Number R-130

## **1. Introduction**

The University of California, Davis, McClellan Nuclear Research Center (MNRC) consists of a research reactor, associated radiography and positioning equipment, and a wide variety of equipment to support broad-based research activities. This MNRC Annual Report is published each year in support of the license provided by the United States Nuclear Regulatory Commission (NRC). The aforementioned license is for the operation of a steady-state TRIGA™ reactor with pulsing and square wave capability.

It is the primary intent of this document to provide information relevant to the safe operation of the UCD/MNRC. A brief description of the MNRC facility and administration is followed by operational events and health physics information concerning this facility during CY 2018.

## **2. UCD/MNRC Facility Description**

The UCD/MNRC is located on the McClellan Industrial Park site; the reactor is housed in Building 258. The McClellan Industrial Park site is approximately 2600 acres, located eight miles northeast of Sacramento, California.

The UCD/MNRC facility is a three level 14,720 sq. ft. rectangular-shaped enclosure that surrounds a 2 MW research reactor. The UCD/MNRC provides four neutron beams to four bays for radiography and other research and commercial activities. All four bays are capable of using radiography film techniques, but 3 normally uses electronic imaging devices. Space, shielding and environmental controls are provided by the enclosure for neutron radiography operations performed on a variety of samples. Adequate room has been provided to handle the components in a safe manner.

In addition to the radiography bays, the UCD/MNRC reactor also has several in-core facilities ranging from a pneumatic tube system to a central irradiation facility.

For more detailed information on the UCD/MNRC project, the reader is referred to the UCD/MNRC Safety Analysis Report.

### **3.0 UCD/MNRC Administration**

UCD/MNRC Organization. The UCD/MNRC is licensed by the Nuclear Regulatory commission (NRC) to operate under the provisions of operating license R-130.

The University of California Regents have designated the Chancellor at UC Davis to be the license holder. The UCD Chancellor has in-turn delegated the Vice Chancellor for Research to be the licensee of record.

The UCD/MNRC is under the direction of the UCD/MNRC Director.



**4.0 Facility Modifications (Section 50.59 of 10CFR Part 50), and experiments.**

None

**5.0 Approved Changes to Experiments**

None

**6.0 Licensing and Regulatory Activities**

**6.1 NRC Items**

- a. The Nuclear Regulatory Commission conducted a semi-annual inspection the week of 8 January 2018. No significant findings reported.
- b. The Nuclear Regulatory Commission conducted an inspection the week of 27 August 2018. No significant findings reported.
- c. Al Adams and Linh Tran visit the facility for meetings and a tour of the facility on 5 September 2018
- d. UCD/MNRC submits facility relicensing package to the NRC on 29 June 2018. Timely renewal confirmation received in August from NRC

**6.2 Nuclear Safety Committee (UCD/NSC)**

- a. The Nuclear Safety Committee held its semi-annual meetings on 27 February and 20 August 2018.
- b. The Nuclear Safety Committee performed an Operations audit for 2017 on 25 February 2018.
- c. The Nuclear Safety Committee performed an audit of the Radiation Safety Program on 30 October 2018.
- d. The Nuclear Safety Committee performed a Security audit on 17 December 2018.

**7.0 OPERATIONS**

**OPERATING HISTORY:**

TOTAL OPERATING HOURS THIS YEAR:	1358.6
TOTAL OPERATING HOURS:	53025.77
TOTAL MEGAWATT HOURS THIS YEAR:	1261.48
TOTAL MEGAWATT HOURS:	67499.65
TOTAL NUMBER OF PULSES PERFORMED THIS YEAR:	0
TOTAL NUMBER OF PULSES PERFORMED:	484

### 7.1 UNSCHEDULED REACTOR SHUTDOWNS and NOTED PROBLEM AREAS:

In 2018, there were three (3) unscheduled reactor shutdowns at the MNRC reactor facility. The following is a list of the unscheduled shutdowns:

#### 2017 UNSCHEDULED REACTOR SHUTDOWNS

Type of Failures	Total Number
CSC	0
Other	3
TOTAL NUMBER OF UNSCHEDULED SHUTDOWNS IN 2018	3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CSC	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	1	0	0	1	0	0	0	1	0
Notes				1			2				3	

#### Notes:

1. Shim 4 Foot switch.
2. Inadvertent Reactor Room Manual Scram. Operator error.
- 3: Loss of Exhaust Fan-1 (EF-1). Scrammed the reactor.

#### January

1. There were no unscheduled shutdowns in the month of January.
2. There was one callback to the facility in January.
  - a. Spurious fire alarm

#### February

1. There were no unscheduled shutdowns in the month of February.
2. There were no callbacks to the facility in February.

#### March

1. There were no unscheduled shutdowns in the month of March.
2. There was one callback to the facility in March.
  - a. Rod Withdrawal Prohibit (RWP) message and a UPS fault probably due to lightning in the area. Both cleared on Acknowledgement (COA)

#### April

1. There was one unscheduled shutdown in the month of April.
  - a. Shim 4 foot switch sticking. See Anomaly report below.
2. There were no callbacks to the facility in the month of April.

#### May

1. There were no unscheduled shutdowns in the month of May.

2. There were five (5) callbacks to the facility in the month of May.
  - a. 4 UPS faults all Cleared on Acknowledgement.
  - b. One callback was due to a Stack Continuous Air Monitor (CAM) Fault when the particulate channel card failed.

#### **June**

1. There were no unscheduled shutdowns in the month of June.
2. There was one callback to the facility in the month of June.
  - a. Rod Withdrawal Prohibit. Cleared on acknowledgement.

#### **July**

1. There was one unscheduled shutdown in July due to operator error.
2. There were no callbacks to the facility in the month of July.

#### **August**

1. There were no unscheduled shutdowns in the month of August.
2. There no callbacks to the facility in the month of August.

#### **September**

1. There were no unscheduled shutdowns in the month of September.
2. There was one callback to the facility in the month of September.
  - a. UPS fault. Cleared on Acknowledgement.

#### **October**

1. There were no unscheduled shutdowns in the month of October.
2. There was one callback to the facility in the month of September.
  - a. Staging Area 4 RAM alarm due to GM tube failure.

#### **November**

1. There was one unscheduled shutdown in the month of November.
  - a. Loss of EF-1. See Anomaly report below.
2. There was one callback to the facility in the month of November.
  - a. UPS Fault. Cleared on acknowledgement.

#### **December**

1. There were no unscheduled shutdowns in December.
2. There were no callbacks to the facility in the month of December.

## **7.2 ANOMALIES :**

During 2018, there were two anomalies at the MNRC facility and no Radiological Incident Investigations.

### **7.2.1 Shim 4 Foot Switch**

Anomaly Report

Date: 4/26/2018

Time: 1219 hrs

Reactor Status: Operating/Critical leveling power at 50 watts.

After normal reactor operation at 1 MW for 2.22 hours, reactor power was being lowered to 50 watts to set conditions to remove an in-tank experiment. During this reactor power reduction, control rod Shim 4 was lowered enough to activate its rod bottom foot switch which not only stops inward rod motion, but also causes a control rod indication color change (from green to black) on the HiRes monitor in the control room. When the reactor operator attempted to withdraw Shim 4 from that position, the control rod indications on the HiRes monitor did not follow the actual control rod movement nor did the control rod color change back to green. This indicates to the reactor operator that the Shim 4 rod bottom footswitch was stuck.

The reactor was shutdown to investigate.

With the reactor shutdown, Shim 4 was driven out and in several times while the Reactor Supervisor was observing the control rod mechanisms locally. The footswitch assembly operated properly each time and a control rod operability check was performed satisfactorily. Scram time was 0.39 sec.

No repairs or adjustments were made.

### **7.2.2 EF-1 Fan Motor**

Anomaly Report

Date: November 19, 2018

Time: 1446 hrs

Reactor Power Level: Operating normally at 1 MW.

**Describe the reactor conditions prior to the anomaly and what occurred during the anomaly:**

The reactor was operating normally at 1 MW supporting radiography operations in Bays 1 and 2.

At 1446 hours the EF-1 alarm on the Temperature Control Panel (TCP) sounded and it was observed that the EF-1 fan proof light on the TCP was extinguished.

The loss of EF-1 casualty was announced throughout the facility and the reactor was manually scrammed and Air Conditioning unit 1 (AC-1) was secured from the TCP in accordance with the UCD/MNRC Operating Procedures Table 8.2 Responses to operating alarms.

The Facility Director was notified.

**Actions taken to correct the anomaly:**

Investigation into the loss of EF-1 began immediately. The mainline fuses (15 amp) were checked satisfactorily (not blown) and the backup circuit breaker (20 amp) was checked and found to be closed and not in the trip free position (i.e. not open).

The EF-1 controller overloads were reset and it appears that these were the cause of the loss of the fan. After resetting the overloads, EF-1 was restarted and individual phase current readings were taken. Each phase read 4.8 amps with the fan running.

Note: EF-1 has run essentially continuously 24/7/365 for 16 years.

These overloads were installed in the EF-1 controller in 2002 (about 16 years old) and may be degrading. The loading of the reactor room ventilation filters combined with the age of the overloads may be the cause of this event.

**Corrective actions needed to prevent this anomaly from recurring in the future:**

The overloads are being evaluated to determine their normal run current and overload ratings.

There is a very high particulate/smoke level in the surrounding environment as a result of the forest and wild fires ongoing in Northern California. The ventilation filters are being excessively loaded with this material and will be changed out once the fires are out or the atmospheric conditions/air quality significantly improves. After the filters are changed out, EF-1 motor running currents will be checked again.



7.3 MAINTENANCE OTHER THAN PREVENTIVE:

February

System #	Description	Work Performed
5490	Helium Supply	Replace expended Helium Supply bottle

March

System #	Description	Work Performed
5620	Reactor Ventilation	Replaced Rx Room (Normal Path) HEPA filter. DOP test SAT.
1001	Reactor CAM	Repaired overheated lug and wire connection for Reactor CAM blower motor

April

System #	Description	Work Performed
5320	Scram test Circuit	Replaced Fuel Temp #1 Action PAK due to erratic indications.

May

System #	Description	Work Performed
5320	Scram test Circuit	Replaced Fuel Temp #2 Action PAK and both the K3 and K4 relays.
5330	NPP-1000	Replaced failed NPP-1000 (High voltage failure when the Rx was shutdown), with the calibrated spare unit.
5490	Helium Supply	Replace expended Helium Supply bottle
1001	Stack CAM	Replaced failed Stack CAM Particulate channel card.

July

System #	Description	Work Performed
1001	Stack CAM	Replace failed power switch for the Stack CAM blower motor.
5490	Helium Supply	Replace expended Helium Supply bottle



### August

1. MNRC completed the annual reactor maintenance shutdown during the month of August. Technical Specification required periodic maintenance as well as general maintenance was performed.
2. Parametric values noted during testing are as follows:

			<b>Control Rod Worth:</b>	
Transient Rod: \$1.83	Shim 1: \$2.61	Shim 2: \$2.49		
Shim 3: \$2.56	Shim 4: \$2.91	Regulating Rod: \$2.78		

<b>Control Rod Scram Drop Times:</b>				
Transient Rod: 0.36 sec	Shim 1: 0.39 sec	Shim 2: 0.37 sec		
Shim 3: 0.40 sec	Shim 4: 0.39 sec	Regulating Rod: 0.38 sec		

Shutdown Margin: \$6.17

The normal nuclear instrument calorimetric calibration was performed. Both the NPP channel and the NM-1000 channels of the Nuclear Instruments were satisfactory, and no adjustments were required.

At Power Scram values: NPP-1000: 107% indicated, NM-1000: 105% indicated.

System #	Description	Work Performed
5120	Demineralizer System	Replaced all 4 depleted resin bottles

### September

System #	Description	Work Performed
1001	Reactor CAM	Replaced burned wire and lug on Rx CAM pump switch.

### October

System #	Description	Work Performed
5490	Helium Supply	Replaced expended helium supply bottle
1020	Radiation Monitoring	Replaced failed Staging Area 4 RAM with calibrated spare unit.



**November**

<b>System #</b>	<b>Description</b>	<b>Work Performed</b>
5630	Building Ventilation	Replaced F2 filters (due excessive loading from ambient smoke from the Camp fire).
5620	Reactor Room Ventilation	Replaced Rx Room ventilation Prefilter due to smoke loading

**December**

<b>System #</b>	<b>Description</b>	<b>Work Performed</b>
5490	Helium Supply	Replaced expended helium supply bottle

**7.4 Training**

**January**

1. Operations and Radiography personnel completed training on Material Handling, Movement, and storage for Pressure Tanks.
2. Facility personnel completed the second half of the 2017 Emergency Drill.
3. One SRO completed training on several modules on Nuclear Theory
4. One SRO completed a review of Normal, Abnormal, and Emergency Procedures.
5. Hosted and conducted training for the Elk Grove High School (Classroom and Practical Lab training).
6. Hosted and conducted training for the Fairfield High School (Classroom and Practical Lab training).

**February**

1. One trainee completed training on Building Cranes and Crane Operation.
2. Hosted and conducted training for the Douglas Middle School (Classroom and Practical Lab training).
3. Hosted and conducted training for two STEM Class from Gold River School (Classroom and Practical Lab training).

**March**

1. Hosted and conducted training for STEM Class from Gold River School (Classroom and Practical Lab training).

**April**

1. All Facility personnel completed Annual ALARA and annual safety training.



2. 4 Senior Reactor Operators completed their Biannual Requalification examination satisfactorily.
3. Hosted and conducted training for UCB NE 104 class (Classroom and NAA experiment).

#### **May**

1. One Senior Reactor Operator completed training on several modules on Design and Operating Characteristics.
2. One Senior Reactor Operator completed training on document changes.
3. Conducted training for the UCD Physics class. (Irradiations and Transient Rod worth practical and Alpha T determination).
4. Conducted training and tours for EAOP Classes.

#### **June**

1. Two Senior Reactor Operators completed their Biannual Medical Exams.

#### **July**

1. MNRC conducted summer school classes for the University COSMOS program.

#### **August**

1. All licensed operators successfully completed the Radiation Safety for Operators training.
2. All Senior Reactor Operators completed Fuel and Fuel Handling training.
3. Hosted and conducted training for University of California Davis NSSC group. (Classroom and Practical Lab training)
4. Hosted and conducted training for Sac City College. (Classroom and Practical Lab training)

#### **September**

1. Two Senior Reactor Operators completed training on Normal, Abnormal and Emergency Procedures.
2. All Senior Reactor Operators completed the Annual Operators Examination.

#### **October**

1. Two Senior Reactor Operators completed Nuclear Theory training.
2. Two Senior Reactor Operators completed several modules on Nuclear Theory.

#### **November**

1. One Senior Reactor Operator completed training on Normal, Abnormal and Emergency Procedures.

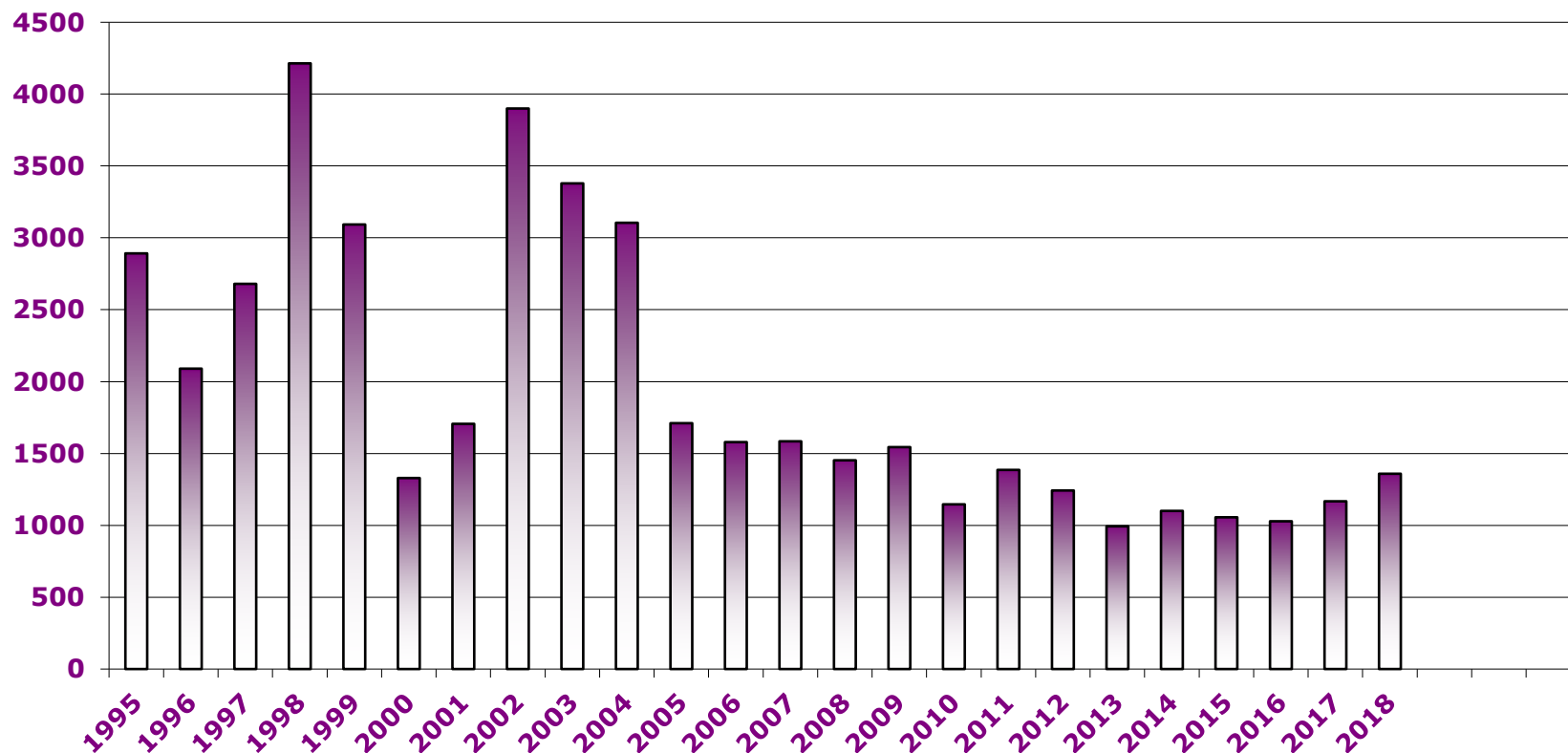
#### **December**

1. Two Senior Reactor Operators completed training on Normal, Abnormal and Emergency Procedures.



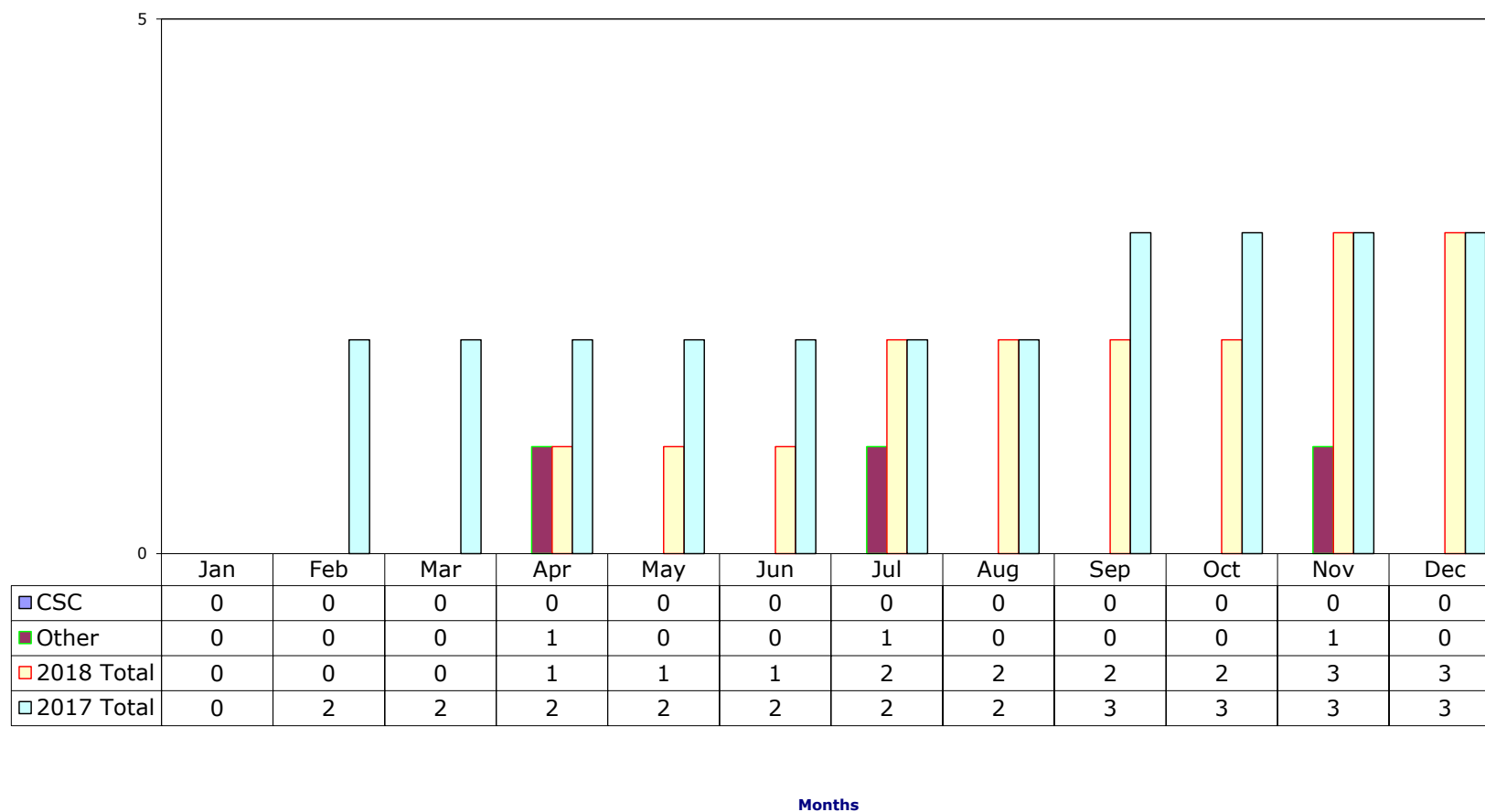


■ **Operating Hours**



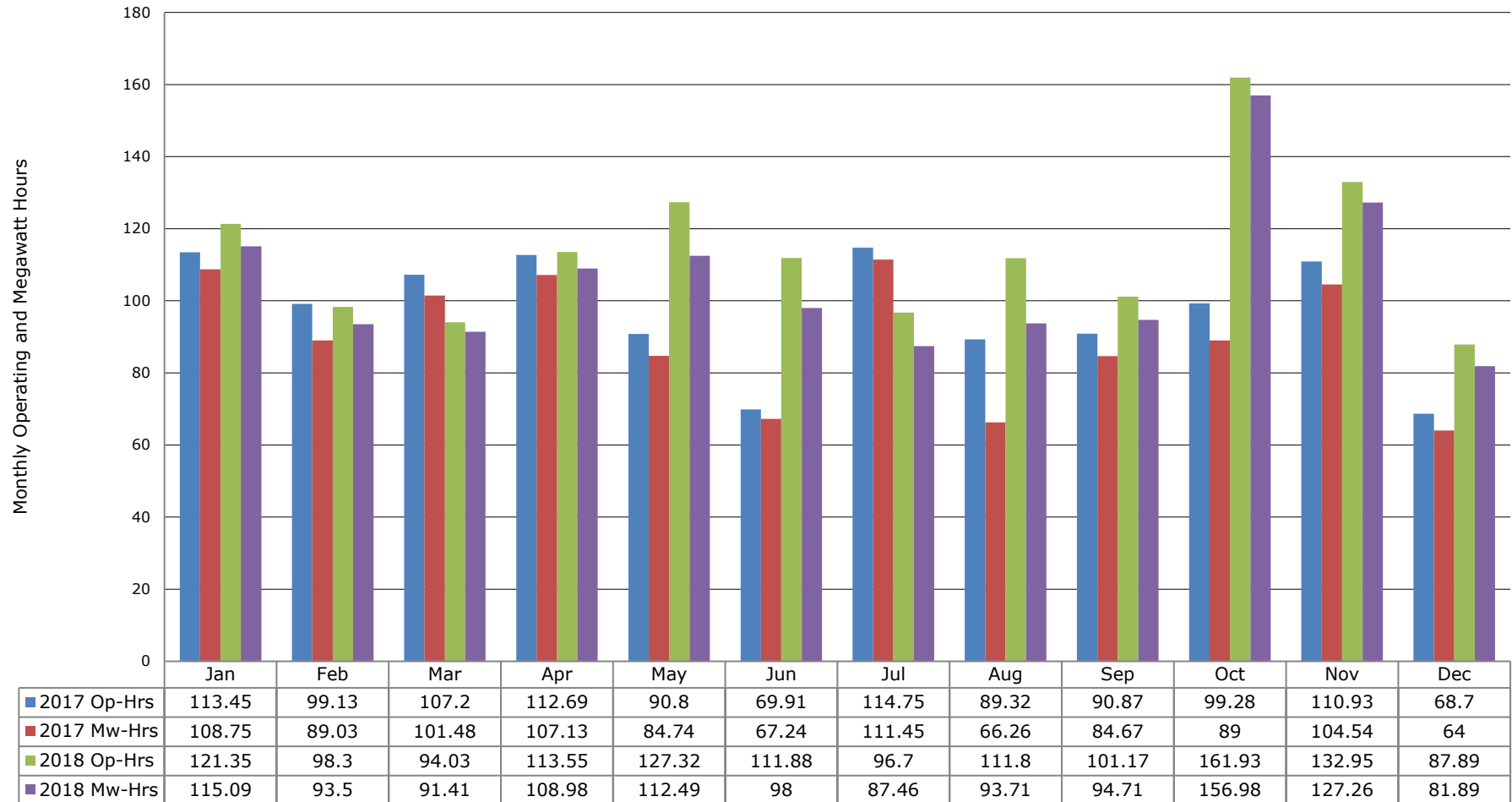


## Unscheduled Reactor Shutdowns 2018



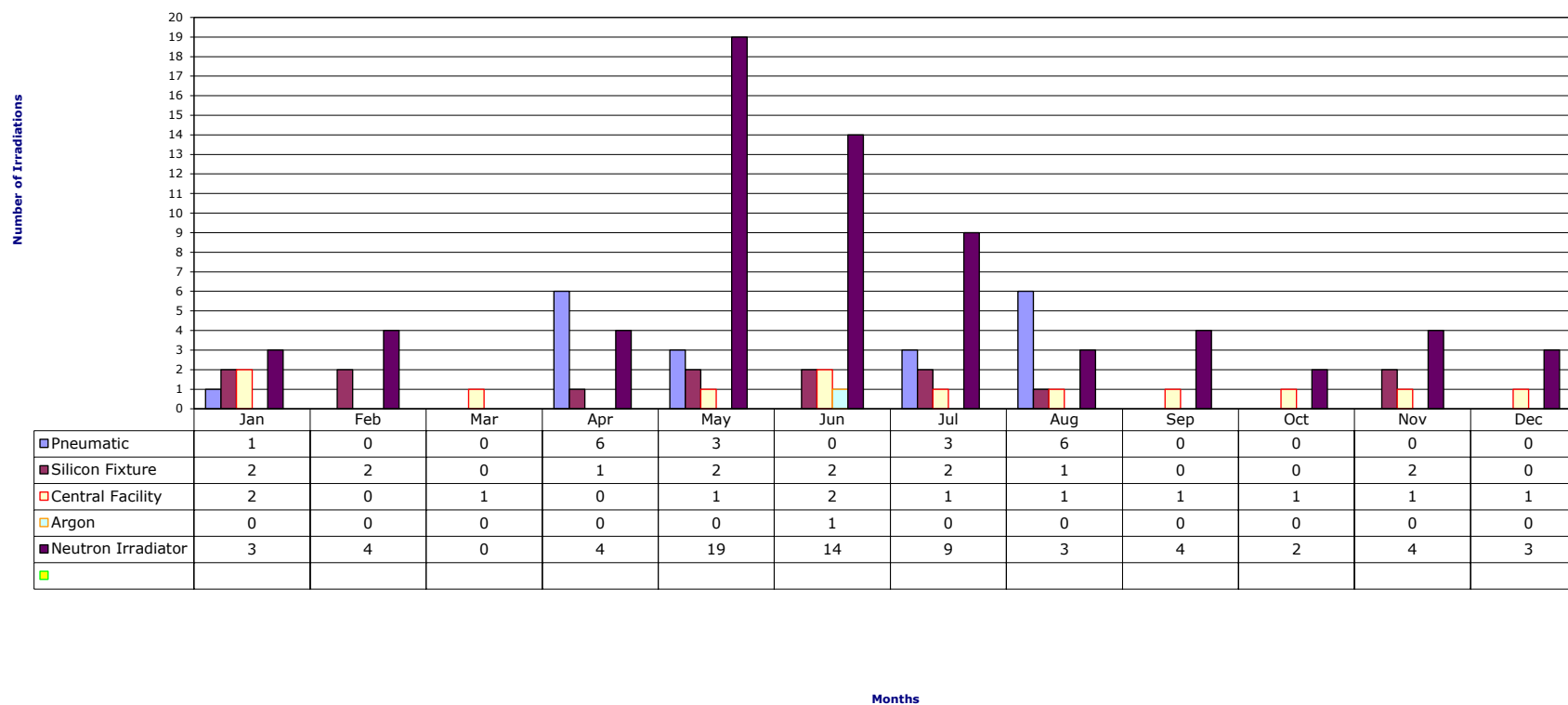


### Reactor Hours 2018





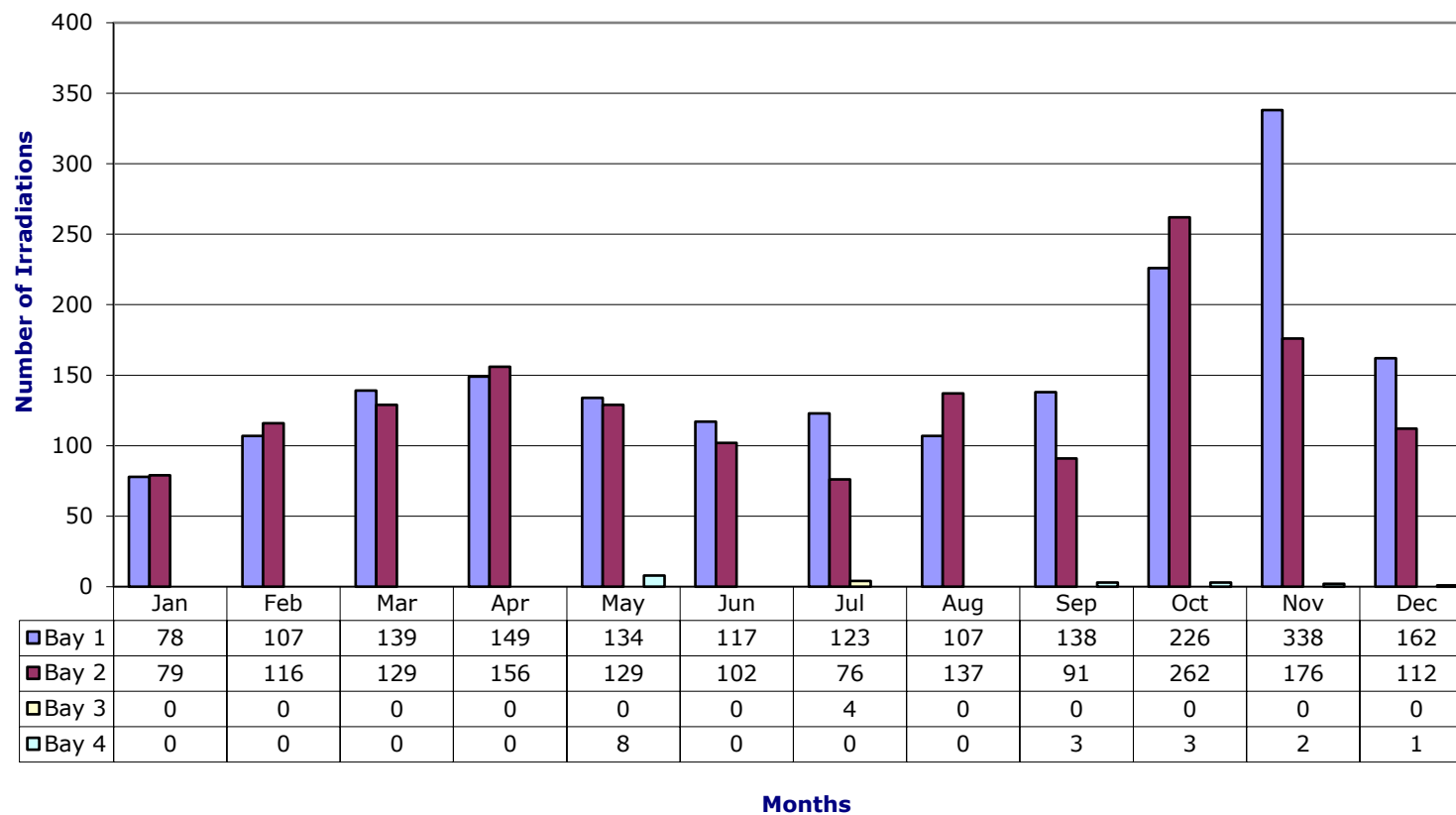
**Reactor Tank Irradiation Facilities 2018**





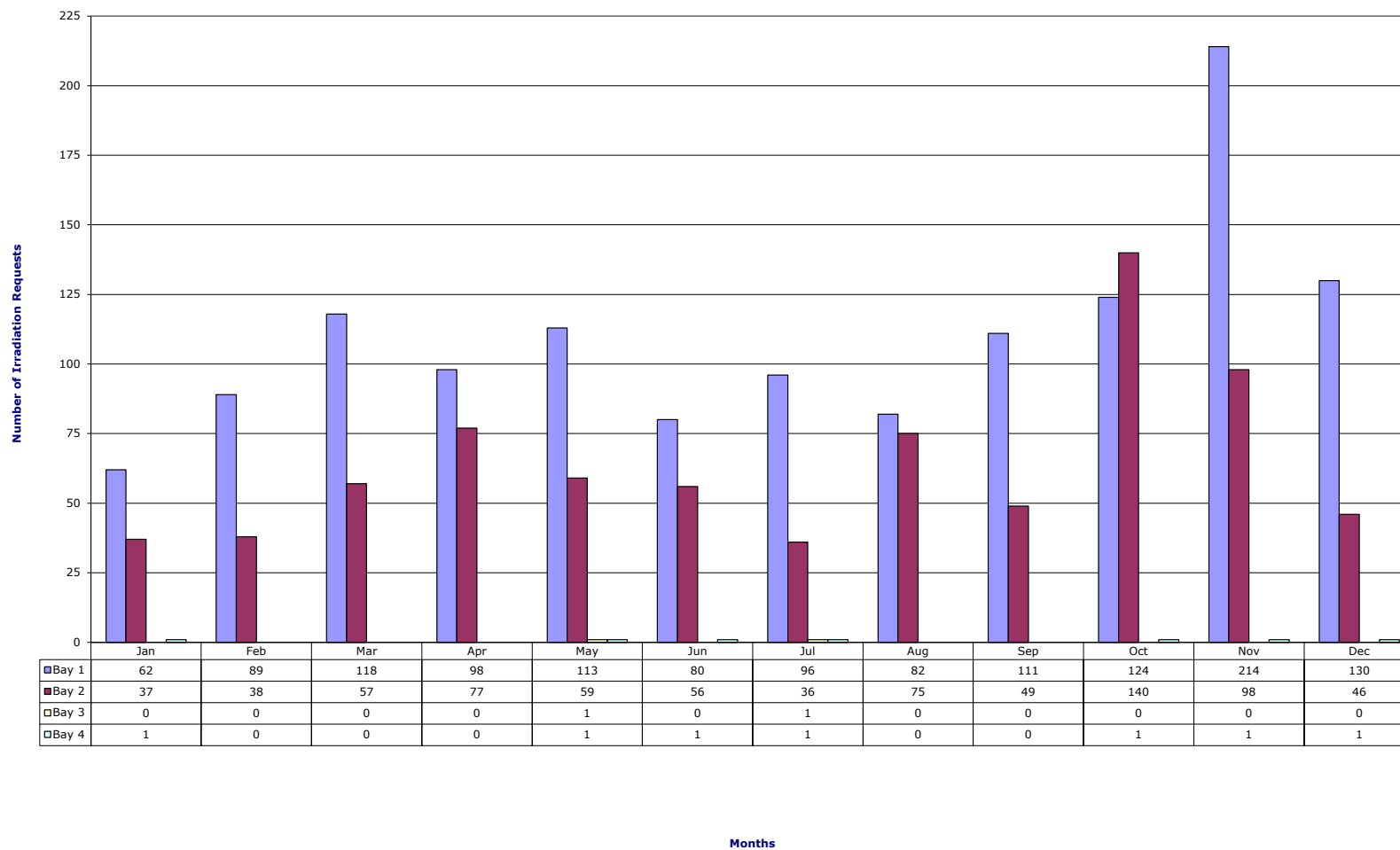


## ***Bay Utilization (Shutter Operations) 2018***





**Bay Irradiation Requests Completed 2018**





## 8.0 **Radioactive Effluents**

A summary of the nature and amount of radioactive effluents released or discharged to the environment beyond the effective control of the MNRC, as measured at or prior to the point of such release or discharge, include the following:

### 8.1 **Liquid Effluents**

No liquid effluents were released during 2018.

### 8.2 **Airborne Effluents**

Airborne radioactivity discharged during 2018 is tabulated in Table 1 below.

**TABLE 1  
2018 SUMMARY OF AIRBORNE EFFLUENTS**

MONTH	TOTAL EST. QUAN. Ar-41 RELEASED	EST. MAX AVG. CONC. OF Ar-41 IN UNRESTRICTED AREA <sup>(1)(3)</sup>	FRACTION OF APPLICABLE 10CFR20 Ar-41 CONC. LIMIT FOR UNRESTRICTED AREA <sup>(1)</sup>	EST. DOSE <sup>(2)</sup> FROM Ar-41 FOR UNRESTRICTED AREA <sup>(1)</sup>	FRACTION OF APPLICABLE 10CFR20 DOSE CONSTRAINT FOR UNRESTRICTED AREA <sup>(1)(4)</sup>	TOT. EST. QUANTITY OF ACT. IN PART. FORM WITH HALF-LIFE >8 DAYS	AVERAGE CONC. OF PART. ACT. RELEASED WITH HALF-LIFE > 8 DAYS
	(Ci)	(uCi/ml)	(%)	(mrem)	(%)	(Ci)	(uCi/ml)
JAN	2.44	1.43E-10	1.4%	0.87	8.70%	NONE	NONE
FEB	2.18	1.28E-10	1.3%	0.78	7.78%	NONE	NONE
MAR	2.49	1.46E-10	1.5%	0.89	8.88%	NONE	NONE
APR	2.19	1.28E-10	1.3%	0.78	7.82%	NONE	NONE
MAY	1.71	9.98E-11	1.0%	0.61	6.08%	NONE	NONE
JUN	1.67	9.74E-11	1.0%	0.59	5.93%	NONE	NONE
JUL	1.53	8.94E-11	0.9%	0.54	5.44%	NONE	NONE
AUG	2.15	1.26E-10	1.3%	0.76	7.65%	NONE	NONE
SEP	1.78	1.04E-10	1.0%	0.63	6.31%	NONE	NONE
OCT	3.13	1.83E-10	1.8%	1.11	11.11%	NONE	NONE
NOV	2.16	1.26E-10	1.3%	0.77	7.67%	NONE	NONE
DEC	1.45	8.46E-11	0.8%	0.51	5.15%	NONE	NONE
TOT	24.87					NONE	NONE
AVG	2.07	1.20 E-10	1.2%	0.74	7.38%		

- (1) This location is 240 meters downwind which is the point of maximum expected concentration based on the worst case atmospheric conditions (see MNRC SAR Chapter 11).  
 (2) Based on continuous occupancy and the calculation techniques used in Appendix A of the MNRC SAR (Ar-41 at 2.3E-10 uCi/ml continuous for one year equals 1.4 mrem).  
 (3) 10CFR20 Limit for concentration is 1E-8 (Appendix B, Table 2);  
 (4) Constraint for dose is 10 mrem/year [10CFR20.1101(d)]



### 8.3 Solid Waste

No solid radioactive waste was shipped this year.

### 9.0 Radiation Exposure

Radiation exposure received by facility operations personnel, facility users, and visitors during 2018 is summarized in Table 2 below.

**TABLE 2  
 2018 SUMMARY OF PERSONNEL RADIATION EXPOSURES**

	NUMBER OF INDIVIDUALS	AVERAGE TEDE PER INDIVIDUAL  (mrem)	GREATEST INDIVIDUAL TEDE  (mrem)	AVERAGE EXTREMITY (1)  (mrem)	GREATEST EXTREMITY  (mrem)
<b>FACILITY PERSONNEL</b>	6	65	149	295	1652
<b>FACILITY USERS</b>	21	<1.0	2	*	*
<b>VISITORS</b>	970	<1.0	2	*	*

(1) Only 4 individuals received extremity exposure

\* Extremity monitoring was not required.



## 10.0 Radiation Levels and Levels of Contamination

Radiation levels and levels of contamination observed during routine surveys performed at the MNRC during 2018 are summarized in Table 3 below.

**TABLE 3**  
**2018 SUMMARY OF RADIATION LEVELS AND CONTAMINATION LEVELS**  
**DURING ROUTINE SURVEYS**

	<b>AVERAGE (mrem/hr)</b>	<b>HIGHEST (mrem/hr)</b>	<b>AVERAGE (dpm/100cm<sup>2</sup>)</b>	<b>HIGHEST (dpm/100cm<sup>2</sup>)</b>
OFFICE SPACES	<0.1	<0.1	<5000 <sup>(1)</sup>	<5000 <sup>(1)</sup>
REACTOR CONTROL RM	<0.1	<0.1	<5000 <sup>(1)</sup>	<5000 <sup>(1)</sup>
RADIOGRAPHY CONTROL RM	<0.1	<0.1	<5000 <sup>(1)</sup>	<5000 <sup>(1)</sup>
COUNTING LAB	<0.1	<0.1	<5000 <sup>(1)</sup>	<5000 <sup>(1)</sup>
STAGING AREA	<0.1	<0.1	<5000 <sup>(1)</sup>	<5000 <sup>(1)</sup>
FACILITY (I/S Fence)	<0.1	<0.1	<5000 <sup>(1)</sup>	<5000 <sup>(1)</sup>
EQUIPMENT RM	0.41 <sup>(4)</sup>	134 <sup>(5)</sup>	<800 <sup>(2)</sup>	<800 <sup>(2)</sup>
DEMINERALIZER AREA	12 <sup>(4)</sup>	340 <sup>(5)</sup>	<800 <sup>(2)</sup>	<800 <sup>(2)</sup>
REACTOR RM	2.9 <sup>(4)</sup>	2800 <sup>(5)</sup>	<800 <sup>(2)</sup>	<800 <sup>(2)</sup>
RADIOGRAPHY BAYS	0.6 <sup>(3)</sup>	300	<800 <sup>(2)</sup>	<800 <sup>(2)</sup>

(1) <5000 dpm/100 cm<sup>2</sup> = Less than the lower limit of detection for a scanning survey.

(2) <800 dpm/100 cm<sup>2</sup> = Less than the lower limit of detection for a swipe survey.

(3) Due to Bay 1 Storage Areas; all other areas and bays are significantly lower (typically <0.1 mrem/hr).

(4) General area dose rate.

(5) Maximum contact dose rate.



## 11.0 Environmental Surveys

Environmental surveys performed outside of the MNRC during 2018 are summarized in Tables 4 & 5 below. The environmental survey program is described in the MNRC Facility Safety Analysis Report.

**TABLE 4**  
**2018 SUMMARY OF ENVIRONMENTAL TLD RESULTS**  
**(WITH NATURAL BACKGROUND<sup>(1)</sup> SUBTRACTED)**

	<b>AVERAGE (mrem)</b>	<b>HIGHEST (mrem)</b>
ON BASE (OFF SITE 1-20 & 64)	7	16
ON SITE (SITES 50 – 61 & 65-71)	12	20

(1) Natural background assumed to be the off base (Sites 27-42) average of 29 mrem.



**TABLE 5**  
**2018 SUMMARY OF RADIOACTIVITY IN WELL WATER**

	<b>ALPHA (pCi/l)</b>	<b>BETA (pCi/l)</b>	<b>TRITIUM (pCi/l)</b>	<b>Cs-137 (pCi/l)</b>
AVERAGE	<MDA	3.68	<MDA	<MDA
HIGHEST	<MDA	5.91	<MDA	<MDA

MDA is the minimum detectable activity at the 95% confidence level.

The MDA range for the analyzed radionuclides (pCi/L).

	MIN	MAX
Alpha	1.4	2.53
Beta	0.99	1.72
Tritium	232	266
Cs-137	1.12	1.62