ZION SOLUTIONS LLC
An EnergySolutions Company

May 12, 2023 ZS-2023-0012

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Zion Nuclear Power Station, Units 1 and 2
Facility Operating License Nos. DPR-39 and DPR-48
NRC Docket Nos. 50-295, 50-304 and 72-1037

Subject: Zion Nuclear Power Station, Units 1 & 2 and Independent Spent Fuel Storage Installation 2022 Annual Radiological Environmental Operating Report

In accordance with the Zion Nuclear Power Station (ZNPS) Quality Assurance Project Plan (QAPP), Appendix B, Section 5.7.2 "Annual Radiological Environmental Operating Report"; and Certificate of Compliance (CoC) No. 1031 for the MAGNASTOR SYSTEM, Appendix A, Technical Specification Section 5.1, "Radioactive Effluent Control Program," Zion*Solutions* is submitting the 2022 Annual Radiological Environmental Operating Report for Units 1 & 2 and the Independent Spent Fuel Storage Installation (ISFSI).

ZNPS QAPP Appendix B, Section 5.7.2 requires submittal of an Annual Radiological Environmental Operating Report before May 15 of each year. CoC Technical Specification Section 5.1 requires submittal of an Annual Radioactive Effluent Control Program report which may be incorporated into the report for the facility operating license. The attachment to this letter is the Annual Radiological Environmental Operating Report for Units 1 & 2 and the ISFSI.

There are no new regulatory commitments in this submittal.

If you have any questions about this submittal, please contact Mr. Randell W Heredia at (949) 943-7366.

Respectfully,

Amy C Hazelhoff Digitally signed by Amy C Hazelhoff
Date: 2023.05.12 16:04:39 -04'00'

Amy C. Hazelhoff
Senior Vice President Regulatory Affairs

cc: Amy Snyder, U.S. NRC Senior Project Manager
Service List

Attachment:
2022 Annual Radiological Environmental Operating Report

Zion Nuclear Power Station, Unit 1 and 2 License Transfer Service List

cc:

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Zion*Solutions* LLC
ZS-2023-0012: Attachment

ATTACHMENT

2022 Annual Radiological Environmental Operating Report

Docket No: 50-295
50-304
72-1037

ZION NUCLEAR POWER STATION

Annual Radiological
Environmental Operating Report

1 January through 31 December 2022

Prepared By
Zion Solutions, LLC

ZION SOLUTIONS LLC
An EnergySolutions Company

Zion Nuclear Power Station
Zion, IL 60099

May 2023

Table Of Contents

Appendix C

Appendix E Errata Data

Intentionally blank as there is no errata data for 2022 period

I. Summary and Conclusions

This report on the Radiological Environmental Monitoring Program (REMP) conducted for the Zion Nuclear Power Station (ZNPS) by Zion*Solutions* (ZS) covers the period 1 January 2022 through 31 December 2022. Zion Station started decommissioning in 2010 and is nearing completion. The termination of Zion's license(s) is under review by the Nuclear Regulatory Commission and once approved, will result in a reduction of the licensed facility's footprint encompassing the ISFSI for continued site storage of the Spent Nuclear Fuel and Greater Than Class C Waste (GTCC) in sealed and shielded canisters until the national repository is ready to receive these.

The Station is currently completing license termination actions required to terminate the stations license and in terms of being a federally licensed waste storage facility, is an ISFSI only station.

In 2022, 600 analyses were performed on 200 samples. These samples include a full year of direct dose TLD monitor results. In assessing all the data gathered for this report and comparing these results with preoperational data, it was concluded that the decommissioning of ZNPS had no adverse radiological impact on the environment.

Environmental gamma radiation measurements were performed quarterly using thermoluminescent dosimeters (TLDs).

II. Introduction

The Zion Nuclear Power Station (ZNPS), consisted of two 1,100 MWt pressurized water reactors, was owned and operated by Exelon Corporation, and is located in Zion, Illinois adjacent to Lake Michigan. The site is located on the western shore of Lake Michigan, approximately 50 miles north of Chicago, Illinois. Unit No. 1 went critical in December 1973. Unit No. 2 went critical in September 1974. The plant permanently ceased operation in January of 1998 and has been permanently defueled, and except for the Independent Spent Fuel Storage Installation (ISFSI); no above-ground structures remain on site. All structures were surveyed, characterized, demolished, and shipped off site as waste, including some structural material discovered in 2022. Some clean construction debris was used as backfill in accordance with the License Termination Plan (LTP). The only known sources of radioactive material on site include spent fuel and GTCC waste stored in canisters on the Independent Spent Fuel Storage Installation (ISFSI) and trace amounts of radioactive material in backfilled structures and surface soil per the Station's LTP. This report covers those analyses performed by Mirion Technologies on samples collected during the period 1 January 2022 through 31 December 2022.

A. Objectives of the REMP

The objectives of the REMP are to:

1. Provide data on measurable levels of radiation and radioactive materials at and beyond the site boundary, in public areas and in the environment.
2. Evaluate the relationship between quantities of radioactive material released from the plant and resultant radiation doses to individuals from principal pathways of exposure.

B. Implementation of the Objectives

The implementation of the objectives is accomplished by:

1. Identifying significant exposure pathways
2. Establishing baseline radiological data of media within those pathways
3. Continuously monitoring those media before, during and after Station operation to assess Station radiological impacts (if any) on man and the environment.

III. Program Description

A. Sample Collection (Performed between January 1 and December 2022)

Samples for the ZNPS REMP were collected byZS personnel and/or Zion Solution Contractors. The sampling methods used by Environmental Inc. are listed in Table B-2.

Ambient Gamma Radiation

Direct radiation measurements were made with Panasonic Environmental TLD type 814 with 3 $CaSO_4$ elements. Each location consisted of 2 TLD sets. The TLD locations were placed on, around and surrounding the ZNPS site at the following locations in 2022, as specified by the requirements of revision 12 to the ODCM:

B. Sample Analysis

Sample Analysis performed by Mirion once received from ZS following sample (TLD) change outs in the field. In order to analyze the TLD results,3 of the 4 calciumSO4 chips are read out by heating them. When the CaSO4 chips absorb gamma energy, the electrons in the crystal structure are excited and end up in a higher orbit. Heating these chips results in the electron giving up its excess energy in the form of visible light that is directly proportional to the Gamma energy absorbed. The detected and quantified light emission is converted to a numerical dose and reported as such, The MDA for these chips is 10 mrem per calendar quarter. The reader will convert the light emission to a numerical dose in units of milli Roentgen per quarter (mR/qtr) and print the reported absorbed dose for each chip. Mirion typically uses chip E4 for the reported dose, but has the results from the other chips in the event these are needed due to chip failure.

Inner Ring: Z-101, Z-103, Z-106, Z-108, Z-109, Z-110, Z-111, Z-112, Z-121, Z-124, Z-125, Z-129, Z-130, Z-131, Z-150, Z-151, Z-152, Z-153, Z154, Z-155

Outer Ring: Z-113, Z-114, Control: Z-13

The specific TLD locations were determined by the following criteria:

1. The presence of relatively dense population.
2. Site meteorological data taking into account distance and elevation for each of the sixteen–22 1/2-degree sectors around the site, where estimated annual dose from ZNPS, if any, would be most significant.
3. On hills free from local obstructions and within clear line of sight to construction activities (where practical) and the ISFSI;

(Two TLDs - each comprised of three $CaSO_4$ elements enclosed in plastic - were placed at each location approximately four to eight feet above ground level. The TLDs were exchanged quarterly and sent to Mirion Technologies for analysis.)

4. Ambient gamma radiation levels at various locations on and off site up to 10 miles away (control) using multi-chip thermos luminescent dosimeters (TLDs).

C. Data Interpretation

The radiological and direct radiation data collected prior to Zion Nuclear Power Station becoming operational were used as a baseline with which these operational data were compared. For the purpose of this report, Zion Nuclear Power Station was considered operational at initial criticality. In addition, data was compared to previous years' operational data for consistency and trending. Several factors were important in the interpretation of the data:

Lower Limit of Detection and Minimum Detectable Concentration

The lower limit of detection (LLD) is defined as the smallest concentration of radioactive material in a sample that would yield a net count (above background) that would be detected with only a 5% probability of falsely concluding that a blank observation represents a "real" signal. The LLD is intended as a before the fact estimate of a system (including instrumentation, procedure, and sample type) and not as an after the fact criteria for the presence of activity. All analyses were designed to achieve the required ZNPS detection capabilities for environmental sample analysis.

The minimum detectable concentration (MDC) is defined above with the exception that the measurement is an after the fact estimate of the presence of activity.

D. Program Exceptions

Second Quarter TLDs had significantly higher doses than expected based on historical results. CR ES-Zion-CR-2022-0076 was initiated to investigate the anomaly. It was concluded that while the TLDs in question were properly collected and shipped to Mirion, the vendor had an issue with their TLD reader at the time of receipt of the shipment. As a result, TLD reading was delayed for approximately two months and as such the TLDs continued to accumulate dose as a result of increased storage time offsite from Zion. The TLD results were adjusted/corrected to subtract the extra dose while stored offsite and these revised readings were validated and submitted into records.

E. Program Changes

There were no changes to the program in 2022. Revision 12 to the ODCM is the revision currently in effect.

IV. Results and Discussion

A. Ambient Gamma Radiation

Ambient gamma radiation levels were measured utilizing Panasonic Environmental Type 814 $CaSO_4$ TLDs. Forty-four TLDs were mounted at 22 locations around the site plus 6 control TLDs at one location 10 miles NW of the site. Results of TLD measurements are listed in Tables C–III.1 to C–III.3, Appendix C.

Most TLD measurements were below 25 mR/quarter, with a range of 12 mR/quarter to 33 mR/quarter. As there are duplicate TLDs posted at each location, the highest value is always reported in Appendix C for each location. When direct dose in 2022 is compared to direct dose the previous seven years (2016-2022) at the four compass points surrounding decommissioning activities within the site boundary, there is a visible drop in direct dose. This is attributed to a steady reduction in source term over the same period, including demolition of structures inside the former protected area, and shipment by rail and truck of the debris to Energy Solutions low level waste facilities in Utah.

When looking at a more specific set of TLD's, those most likely to be impacted by direct radiation from the Independent Spent Fuel Storage Installation (ISFSI) by proximity and line of site positioning inside the site boundary (Figure C-7.1), a significant increase in direct dose is evident in 2015 following completion of the transfer of spent fuel to the ISFSI. After 2015, a drop in direct dose is evident due in part to site source term reduction, and to a lesser extent, decay of the spent fuel. The drop was ERA Evaluation Criteria.

B. Deleted

C. Deleted

D. Errata Data

There is no errata data required for the 2022 time period.

APPENDIX A

RADIOLOGICAL ENVIRONMENTAL MONITORING REPORT SUMMARY

TABLE A-1 RADIOLOGICAL ENVIRONMENTAL MONITORING ANNUAL SUMMARY FOR THE ZION NUCLEAR POWER STATION, 2022

Name of Facility: ZION NUCLEAR POWER STATION **DOCKET NUMBER:** 50-295 & 50-304
Location of Facility: ZION IL **REPORTING PERIOD:** 2022

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	TYPES OF ANALYSIS PERFROMED	NUMBER OF ANALYSES PERFORMED	REQUIRED LOWER LIMIT OF DETECTION (LLD)	INDICATOR LOCATIONS MEAN (f) RANGE	CONTROL LOCATION MEAN (f) RANGE	LOCATION WITH THE HIGHEST ANNUAL MEAN (M) MEAN (f) RANGE	LOCATION WITH THE HIGHEST ANNUAL MEAN (M) STATION # NAME	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
DIRECT RADIATION (MILLI-ROENTGEN/QTR)	TLD QUARTERLY	600	N/A	18.4 (80/80) 12-33	17.8 (24/24) 15-23	27 (4/4) 22-33	Z-131 (INDICATOR) 0.07 MILES NW	0

APPENDIX B

LOCATION DESIGNATION, DISTANCE & DIRECTION, AND SAMPLE COLLECTION & ANALYTICAL METHODS

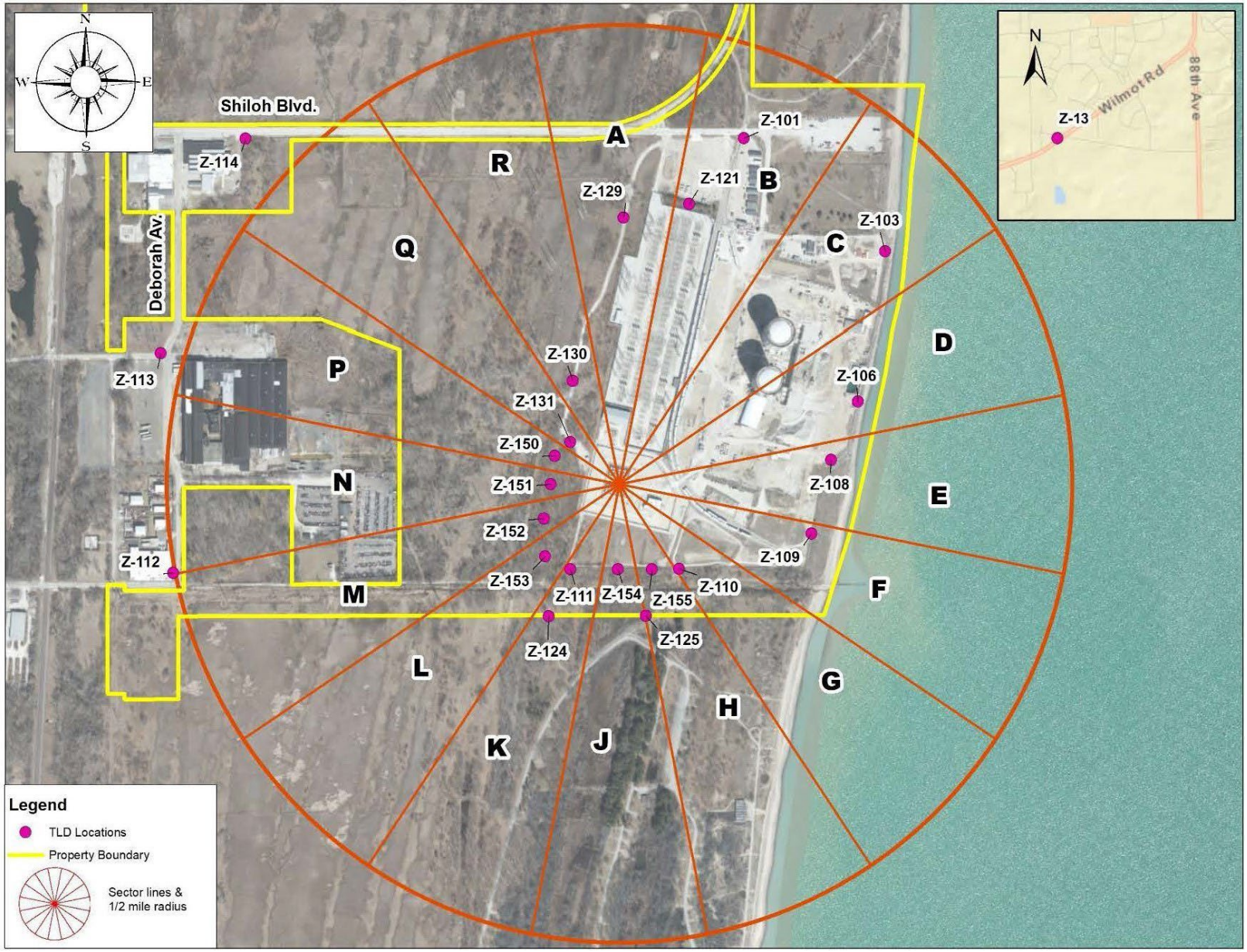
TABLE B-1: Radiological Environmental Monitoring Program - Sampling Locations, Distance and Direction, Zion Nuclear Power Station, 2022

Location	Distance & Direction From Site
A. Environmental Dosimetry -	
TLD Inner Ring	
Z-101-1 and -2	0.40 miles NNE
Z-103-1 and -2	0.39 miles NE
Z-106-1 and -2	0.31 miles ENE
Z-108-1 and -2	0.24 miles E
Z-109-1 and -2	0.22 miles E
Z-110-1 and -2	0.11 miles SE
Z-111-1 and -2	0.11 miles SSW
Z-112-1 and -2	0.50 miles W
Z-121-1 and -2	0.31 miles NNE
Z-124-1 and -2	0.16 miles SSW
Z-125-1 and -2	0.15 miles SSE
Z-129-1 and -2	0.29 miles N
Z-130-1 and -2	0.12 miles NNW
Z-131-1 and -2	0.07 miles NW
Z-150-1 and -2	0.08 miles WNW
Z-151-1 and -2	0.08 miles W
Z-152-1 and -2	0.09 miles WSW
Z-153-1 and -2	0.11 miles SW
Z-154-1 and -2	0.09 miles S
Z-155-1 and -2	0.10 miles SSE
Outer Ring	
Z-113-1 and -2	0.53 miles WNW
Z-114-1 and -2	0.56 miles NW
Control	
Z-13-1 thru -6	13.0 miles NW

Table B-2 Radiological Environmental Monitoring Program - Summary of Sample Collection and Analytical Methods, Zion Nuclear Power Station, 2022

TLD	Thermoluminescent Dosimetry	Quarterly TLDs comprised of two Panasonic Environmental TLD type 814 with 3 CaSO4 elements in each dosimeter at each location.	Mirion Technologies

Figure B-1 Inner and Outer Ring TLD Locations of the Zion Nuclear Power Station, 2022



APPENDIX C

DATA TABLES

Table C-III.1 ~~**All TLD RESULTS FOR ALL LOCATIONS**~~ Quarterly TLD Results for Zion Nuclear Power Station, 2022

ALL TLD RESULTS								
LOCATION	1st Qtr Max	2nd Qtr max	3rd Qtr Max	4 th Qtr Max	Mean	+/- 2SD		TLD TYPE BY LOCATION
Z-129-1 & 2	13	19	16	13	15.3	+/- 5.7		Inner Ring
Z-121-1 & 2	13	19	16	14	15.5	+/- 5.3		Inner Ring
Z-101-1 & 2	12	19	16	14	15.3	+/- 6.0		Inner Ring
Z-103-1 & 2	13	23	18	16	17.5	+/- 8.4		Inner Ring
Z-106-1 & 2	13	21	17	15	16.5	+/- 6.8		Inner Ring
Z-108-1 & 2	14	20	18	15	16.8	+/- 5.5		Inner Ring
Z-109-1 & 2	14	27	19	15	18.8	+/- 11.8		Inner Ring
Z-110-1 & 2	15	22	19	17	18.3	+/- 6.0		Inner Ring
Z-155-1 & 2	16	23	19	17	18.8	+/- 6.2		Inner Ring
Z-125-1 & 2	13	19	17	14	15.8	+/- 5.5		Inner Ring
Z-154-1 & 2	16	24	21	19	20.0	+/- 6.7		Inner Ring
Z-111-1 & 2	15	22	19	17	18.3	+/- 6.0		Inner Ring
Z-124-1 & 2	13	21	17	16	16.8	+/- 6.6		Inner Ring
Z-153-1 & 2	15	22	20	17	18.5	+/- 6.2		Inner Ring
Z-152-1 & 2	18	24	24	18	21.0	+/- 6.9		Inner Ring
Z-151-1 & 2	19	28	25	21	23.3	+/- 8.1		Inner Ring
Z-112-1 & 2	14	22	18	15	17.3	+/- 7.2		Inner Ring
Z-150-1 & 2	19	26	22	20	21.8	+/- 6.2		Inner Ring
Z-131-1 & 2	23	33	28	25	27.3	+/- 8.7		Inner Ring
Z-130-1 & 2	14	22	19	15	17.5	+/- 7.4		Inner Ring
Z-113 1 & 2	13	22	17	14	16.5	+/- 8.1		*Outer Ring*
Z-114-1 & 2	14	21	18	15	17.0	+/- 6.3		*Outer Ring*
mean-inner	15	23	19	17	12	min	33	maximum
mean-outer	14	22	18	15	17	min	22	maximum

18.4 indicator mean
12 indicator minimum
33 indicator maximum

Table C-III.2 MEAN QUARTERLY TLD RESULTS FOR INNER RING, OUTER RING AND CONTROL STATIONS FOR ZION NUCLEAR POWER STATION, 2022[1]

Results in Units of Milli-Roentgen/Quarter
± 2 Standard Deviations of the Station Data (All TLD results)

COLLECTION PERIOD	INNER RING	OUTER RING	CONTROL.
JAN-MAR	15 ± 5	13 ± 2	15 ± 0
APR-JUN	22 ± 6	21 ± 3	21 ± 1
JUL-SEP	19 ± 6	17 ± 2	19 ± 1
OCT-DEC	16 ± 6	14 ± 2	16 ± 1

Table C-III.3 SUMMARY OF THE AMBIENT DOSIMETRY PROGRAM FOR ZION NUCLEAR POWER STATION, 2022

RESULTS IN UNITS OF MILLI-ROENTGEN /QUARTER

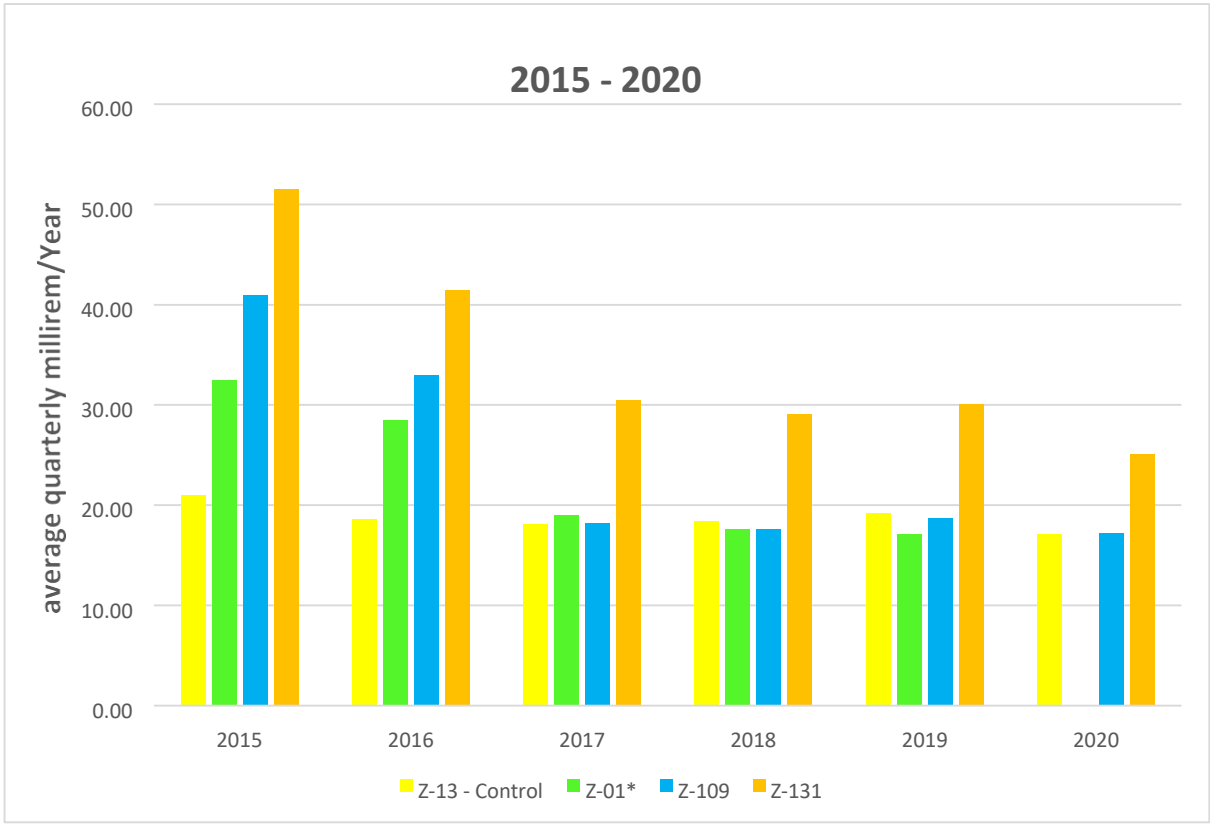
LOCATION	SAMPLES ANALYZED	PERIOD MINIMUM	PERIOD MAXIMUM	PERIOD MEAN ± 2 S.D.
INNER RING	80	12	33	17 ± 6
OUTER RING	8	12	22	15 ± 7
CONTROL	24	15	23	18 ± 5

INNER RING STATIONS - Z-101, Z-103, Z-106, Z-108, Z-109, Z110, Z-111, Z-112, Z-121, Z-124, Z-125, Z-129, Z130, Z-131, Z-150, Z-151, Z-152, Z-153, Z-154, Z-155

OUTER RING STATIONS - Z-113, Z-114

CONTROL STATION - Z-13

FIGURE C-7.1



- - Z-01 (effluent release path) removed in 1st Quarter 2020 due to ODCM Revision 12

Figure C-7.2 - Owner Controlled Boundary