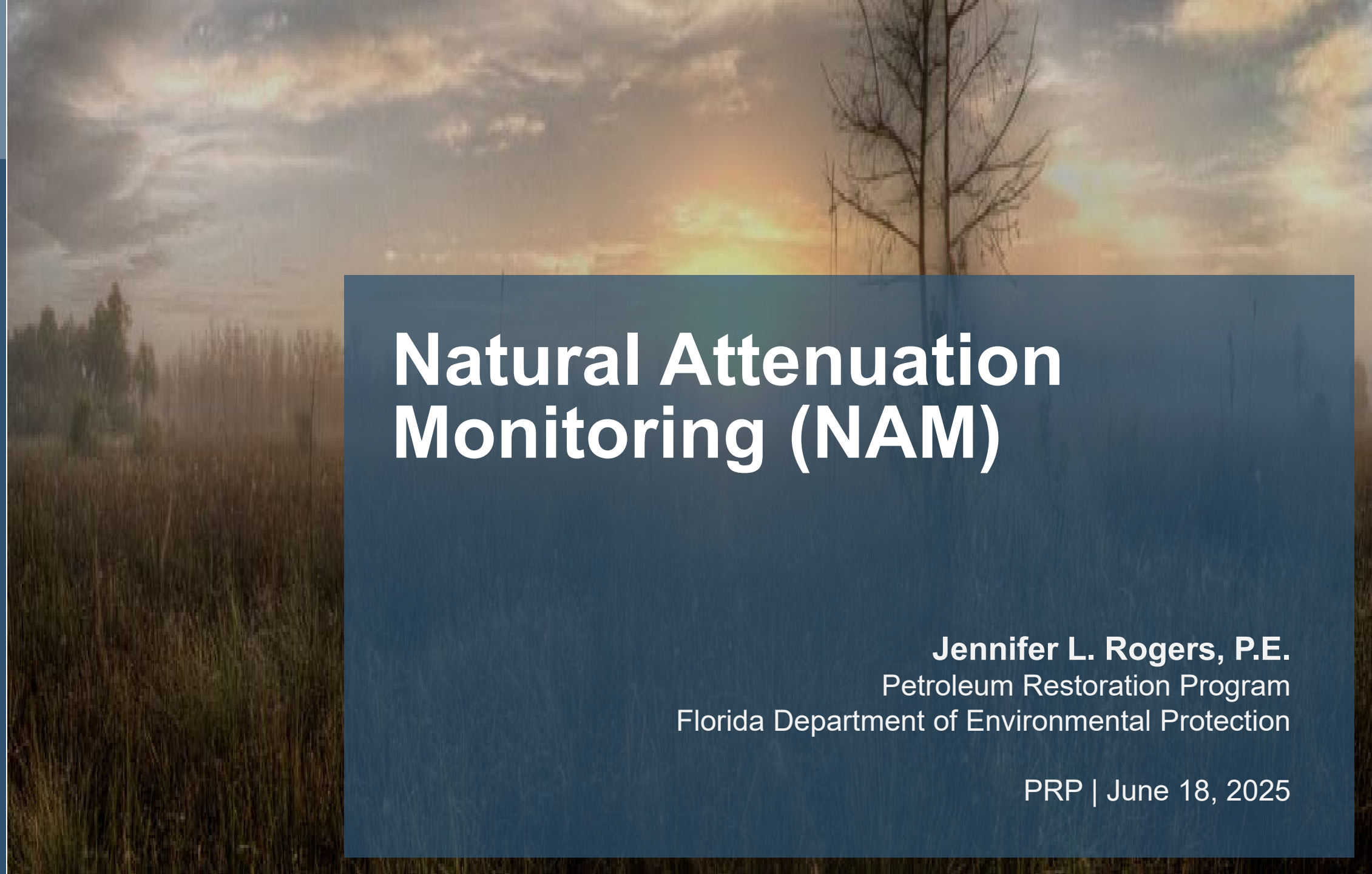

Natural Attenuation Monitoring (NAM)

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Petroleum Restoration Program
Florida Department of Environmental Protection

PRP | June 18, 2025

NATURAL ATTENTUATION MONITORING
AGENDA

Presentation Goals:

- Florida Statute (F.S.) and Florida Administrative Code (F.A.C.) Review.
- Criteria for Natural Attenuation Monitoring (NAM).
- Verifying Progress.
  - Timeframe for Achieving No Further Action (NFA).
  - Action Levels.
  - Expected Reductions.
  - NAM Parameters.
- Cost Effective NAM.
- Reviewing NAM Reports.

Underlined text in the presentation has embedded web links to documents.

NATURAL ATTENTUATION MONITORING

Florida Statute

Florida Statute (F.S.):

- Chapter 376, F.S. - Pollutant Discharge Prevention And Removal.
- Section 376.301, F.S. Definitions for terms used in Sections 376.30-376.317, F.S.
  - Including Section 376.3071, F.S. - Inland Protection Trust Fund (IPTF).
- Section 376.301(25), F.S.
  - "Natural attenuation" means a verifiable approach to site rehabilitation that allows *natural processes* to contain the spread of contamination and reduce the concentrations of contaminants in contaminated groundwater and soil. Natural attenuation processes may include the following: sorption, biodegradation, chemical reactions with subsurface materials, diffusion, dispersion, and volatilization.

NATURAL ATTENTUATION MONITORING

Florida Statute

Florida Statute (F.S.):

- Section 376.301(23), F.S.
  - “Long-term natural attenuation” means natural attenuation approved by the department as a site rehabilitation program task for a period of more than 5 years.

NATURAL ATTENTUATION MONITORING

Florida Statute

Florida Statute (F.S.):

- Section 376.3071(5), F.S. - Site Selection And Cleanup Criteria.
- Section 376.3071(5)(c)2., F.S.
  - Long-term Natural Attenuation Monitoring (LTNAM) when:
    - Free Product removal and other source removal completed.
    - Cost effective.
    - Plume is shrinking or stable.
    - Chemicals/Contaminants of Concern (COCs) are below Natural Attenuation Default Concentrations (NADCs).
    - Plume is confined to source property boundaries.
      - ✓ *If beyond source property, NAM may continue per F.A.C.*
  - If site no longer qualifies for NAM or LTNAM, resume active remediation.

NATURAL ATTENTUATION MONITORING

Florida Statute

Florida Statute (F.S.):

- Section 376.3071(5), F.S. - Site Selection And Cleanup Criteria.
- Section 376.3071(5)(c)2., F.S.
  - "For long-term NAM, if the petroleum products' COCs increase or are not significantly reduced after 42 months of monitoring, or if the plume migrates beyond the property boundaries, active remediation shall be resumed as necessary."
    - 42 months = 3.5 years.
- Section 376.3071(5)(c)2., F.S. sets the stage for "Level 1 Criteria."

NATURAL ATTENTUATION MONITORING

Florida Statute

Florida Statute (F.S.):

- Section 376.3071(5), F.S. - Site Selection And Cleanup Criteria.
- Section 376.3071(5)(c)3., F.S.
  - Allows for NAM if COCs above NADCs when:
    - Cost effective.
    - Adequately protects public health, safety, welfare, water resources, and the environment.
    - Evaluation of site-specific characteristics supports NAM.
- Section 376.3071(5)(c)3., F.S. sets the stage for “Level 2 Criteria.”

NATURAL ATTENTUATION MONITORING

Florida Administrative Code

Florida Administrative Code (F.A.C.):

- Chapter 62-780, F.A.C. - Contaminated Site Cleanup Criteria.
- Rule 62-780.690, F.A.C. Natural Attenuation Monitoring.
  - Paragraph 62-780.690(1)(a) through subparagraph 62-780.690(1)(f)1., F.A.C.
    - Implementation of Section 376.3071(5)(c)2., F.S.
    - Criteria for NAM – Applicability.
      - ✓ “Level 1 Criteria.”

NATURAL ATTENTUATION MONITORING

Florida Administrative Code

Florida Administrative Code (F.A.C.):

- Chapter 62-780, F.A.C. - Contaminated Site Cleanup Criteria.
- Rule 62-780.690, F.A.C. Natural Attenuation Monitoring.
  - Sub-subparagraphs 62-780.690(1)(f)2.a. through 62-780.690(1)(f)2.c., F.A.C.
    - Implementation of Section 376.3071(5)(c)3., F.S.
    - Demonstrate appropriateness of NAM.
      - ✓ “Level 2 Criteria.”

NATURAL ATTENTUATION MONITORING

NAM Criteria

NAM Criteria – Level 1 Criteria – Applicability:

- Meet criteria before NAM starts – Verify criteria maintained during NAM.
- Paragraph 62-780.690(1)(a) through subparagraph 62-780.690(1)(f)1., F.A.C.
  - *Free product is not present, except where removal is not technologically possible, and no fire or explosion hazard exists.*
  - ***AND…***

NATURAL ATTENTUATION MONITORING

NAM Criteria

NAM Criteria – Level 1 Criteria – Applicability:

- Meet criteria before NAM starts – Verify criteria maintained during NAM.
- Paragraph 62-780.690(1)(a) through subparagraph 62-780.690(1)(f)1., F.A.C.
  - *Soil contamination is not present in unsaturated zone, except…*
    - *Leachability-based Cleanup Target Levels (CTLs) may be exceeded if it has been demonstrated the soil is not a continuing source of groundwater contamination {e.g., determination via Synthetic Precipitation Leaching Procedure (SPLP)} or rate of leaching is less than rate of natural attenuation in the groundwater.*
  - ***AND…***

NATURAL ATTENTUATION MONITORING

NAM Criteria

NAM Criteria – Level 1 Criteria – Applicability:

- Meet criteria before NAM starts – Verify criteria maintained during NAM.
- Paragraph 62-780.690(1)(a) through subparagraph 62-780.690(1)(f)1., F.A.C.
  - *Contamination is conducive to natural attenuation.*
  - *Data show an overall decrease in contamination.*
  - ***AND…***

NATURAL ATTENTUATION MONITORING

NAM Criteria

NAM Criteria – Level 1 Criteria – Applicability:

- Meet criteria before NAM starts – Verify criteria maintained during NAM.
- Paragraph 62-780.690(1)(a) through subparagraph 62-780.690(1)(f)1., F.A.C.
  - *Contaminant plume (concentrations of COCs above applicable CTLs) is not migrating beyond Temporary Point of Compliance (TPOC) or vertically.*
  - ***AND…***

NATURAL ATTENTUATION MONITORING

NAM Criteria

NAM Criteria – Level 1 Criteria – Applicability:

- Meet criteria before NAM starts – Verify criteria maintained during NAM.
- Paragraph 62-780.690(1)(a) through subparagraph 62-780.690(1)(f)1., F.A.C.
  - ***AND…*** *<u>either:</u>* subparagraph 62-780.690(1)(f)1., *<u>or</u>* 62-780.690(1)(f)2., F.A.C. is met.
    - Subparagraph 62-780.690(1)(f)1., F.A.C. (Level 1 Criteria):
      - ✓ *Site anticipated to meet NFA criteria as a result of Natural Attenuation;*
      - ✓ *Background or applicable CTLs are not exceeded at TPOC(s); and,*
      - ✓ *Contaminant concentrations do not exceed NADCs.*

NATURAL ATTENTUATION MONITORING

NAM Criteria

NAM Criteria – Level 1 Criteria – Applicability:

- Meet criteria before NAM starts – Verify criteria maintained during NAM.
- Paragraph 62-780.690(1)(a) through subparagraph 62-780.690(1)(f)1., F.A.C.
  - ***AND…*** *<u>either:</u>* subparagraph 62-780.690(1)(f)1. *<u>or</u>* 62-780.690(1)(f)2., F.A.C. is met.
    - Subparagraph 62-780.690(1)(f)2., F.A.C. (Level 2 Criteria):
      - ✓ *Demonstrate the appropriateness of NAM.*

NATURAL ATTENTUATION MONITORING

NAM Criteria

NAM Criteria – Level 2 Criteria – Appropriateness:

- Is NAM Appropriate?
- Meet criteria before NAM starts – Verify criteria maintained during NAM.
- Sub-subparagraphs 62-780.690(1)(f)2.a. through 62-780.690(1)(f)2.c., F.A.C.
  - Technical Evaluation of site-specific conditions;
  - Scientific Evaluation (e.g., model) of plume migration, estimation of expected annual reductions of COCs in wells, and an estimated timeframe for achieving NFA; and,
  - Life-Cycle Cost Analysis of remedial alternatives.

NATURAL ATTENTUATION MONITORING

Verifying Progress

Florida Statute (F.S.):

- Section 376.3071(5)(c)2., F.S.
  - Timeframe for achieving NFA:
    - If COCs are not significantly reduced after 42 months (3.5 years) of monitoring, active remediation shall be resumed, as applicable.
      - If at or beyond 42 months of NAM the continuation of NAM is recommended, Site Manager and/or Technical Reviewer shall review the site status with PRP Chief or Assistant Chief P.E.

NATURAL ATTENTUATION MONITORING

Verifying Progress

Florida Administrative Code (F.A.C.):

- Paragraphs 62-780.690(8)(e) and 62-780.690(8)(f), F.A.C.
  - Action Levels and Expected Reductions:
    - Compare COCs concentration data to:
      - ✓ Action Levels; and,
      - ✓ Expected Reductions.

NATURAL ATTENTUATION MONITORING

Verifying Progress

Action Levels:

- Specified in NAM Plan Approval.
  - NAM Plan Approval Orders for non-program discharges.
  - Template NAM Plan Approval letter for program discharges.
- Should be specific to each contaminant and monitoring well.
- Should not be NADCs.
  - Unless “Level 2 NAM Plan” approved.
  - If COC >NADC – no longer meets “Level 1” criteria for NAM.

NATURAL ATTENTUATION MONITORING

Verifying Progress

Action Levels:

- Examples of Action Levels:
  - For wells within the plume: historical high concentrations or a percent above the average.
  - For cross- or down-gradient wells: first time detection or exceedance of CTLs.

NATURAL ATTENTUATION MONITORING

Verifying Progress

Action Levels:

- If Action Level exceeded, per Chapter 62-780, F.A.C., signed/sealed monitoring report recommends:
  - Additional assessment;
  - Continued NAM;
  - Remedial Action Plan (RAP) for return to active remediation; or,
  - Any other action allowed under Chapter 62-780, F.A.C.

NATURAL ATTENTUATION MONITORING

Verifying Progress

Action Levels:

- Resampling within 30 days to confirm exceedance *is not* specified for NAM.
  - It is *recommended* to resample within 30 days to confirm exceedance of Action Level (unless exceedance anticipated, e.g., potential increasing trend).
    - *Resampling within 30 days to confirm exceedance is specified in Chapter 62-780, F.A.C. for Post Active Remediation Monitoring (PARM).*

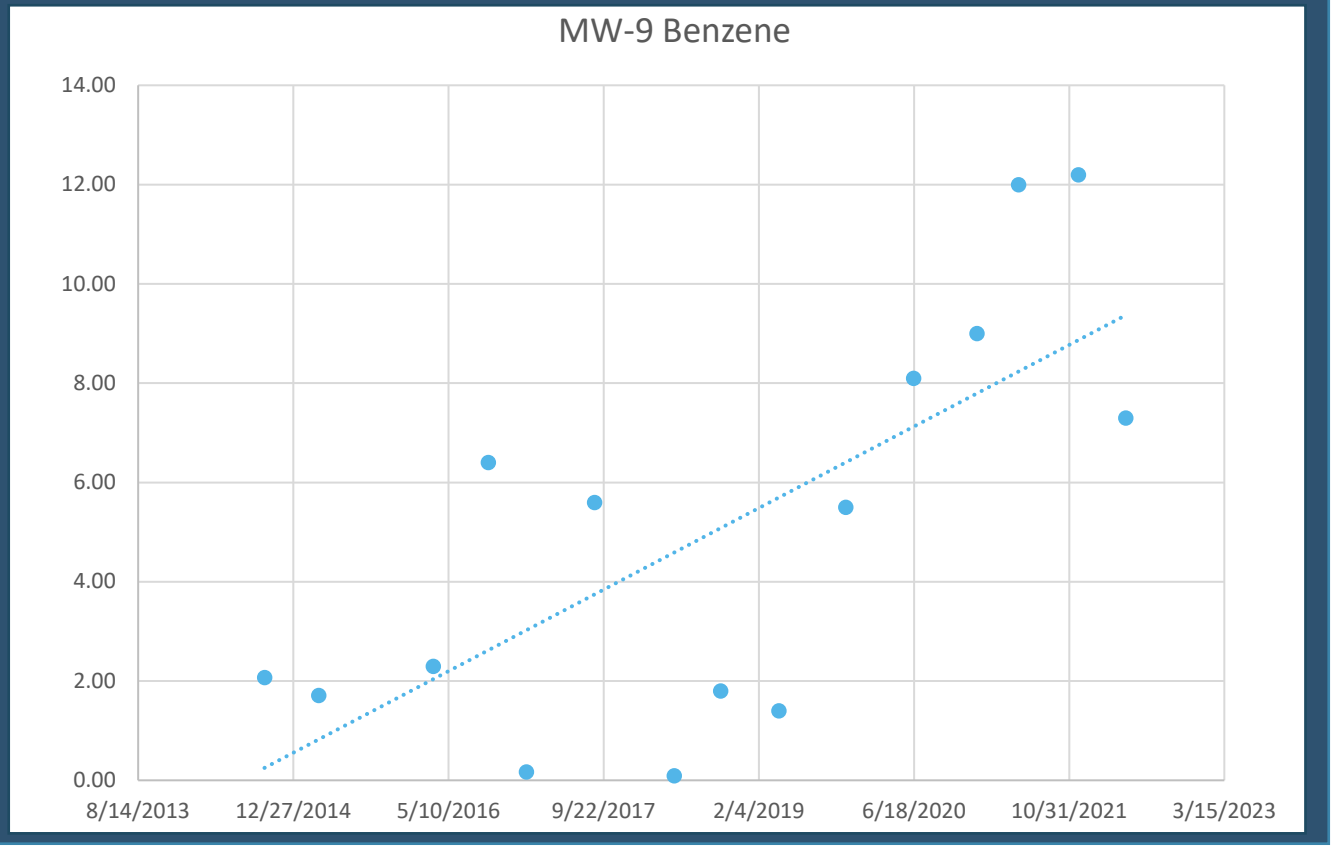
NATURAL ATTENTUATION MONITORING

Verifying Progress

Expected Reductions – Verify Progress:

- Graphing.
  - Example site.

			Benzene	Toluene	Ethylbenzene	Ttl Xylenes
Sept 2012 Sys Start	MW-9	8/10/2012	94	260	230	450
		12/19/2012	0.23 U	0.20 U	0.20 U	0.22 U
		3/24/2013	0.23 U	0.20 U	0.20 U	0.22 U
		6/24/2013	0.23 U	0.20 U	0.20 U	0.22 U
System shutdown		9/25/2013	0.23 U	0.20 U	0.20 U	0.22 U
PARM start >90 days		12/23/2013	0.23 U	0.20 U	0.20 U	0.22 U
		3/7/2014	0.55 I	0.20 U	0.20 U	0.22 U
		9/25/2014	2.07	0.140 U	0.190 U	1.77
		03/18/2015	1.71	0.140 U	0.190 U	1.90
		3/22/2016	2.3	2.9	1.2	1.7 I
NAM		9/15/2016	6.4	3.4	5.6	5.0
		1/16/2017	0.34 U	0.45 U	3.8	1.5 I
		3/6/2017	NS	NS	NS	NS
		8/23/2017	5.6	1.4	2.2	2.0 I
		5/7/2018	0.18 U	0.56 I	1.0	1.7 I
		10/4/2018	1.8	0.45 U	0.97 I	0.93 I
		4/9/2019	1.4	0.45 U	0.94 I	0.78 I
		11/11/2019	5.5	0.45 U	0.93 I	0.56 U
		6/16/2020	8.1	1.0	6.2	7.1
		1/6/2021	9.0	0.49 U	7.4	10
		5/21/2021	12	0.66 U	13	7.6
		11/29/2021	12.2	0.30U	4.1	0.72U
		5/1/22	7.3	0.66 U	1.3	1.3 U



NATURAL ATTENTUATION MONITORING

Verifying Progress

Expected Reductions – Verify Progress:

- Percent Reduction Calculations - LTNAM Reduction Worksheet.
  - Average Reduction – sum of all individual COC percentage changes for all individual key wells during monitoring period divided by the total number of measurements.
  - Example site.

LONG TERM NATURAL ATTENUATION MONITORING REDUCTION WORKSHEET

Facility Name		Report Date	
Facility ID #		Baseline Sampling Date	

MW	Key Monitoring Well	Conc	Concentration of COC (must be >GCTL at baseline) in ug/L
COC	Contaminant of Concern (i.e., Benzene, Toluene,	GCTL	Groundwater Cleanup Target Level

				LTNAM Monthly Monitoring Period Concentrations									
MW	COC	GCTL	Baseline Conc	4	11	20	25	31	38	45	52	56	42 mo % Reduction
MW-9	Benzene	1	6.4	0.17	5.6	0.09	1.8	1.4	5.5	8.1	9	12	-27%
		Aggregate Reduction		97%	13%	99%	72%	78%	14%	-27%	-41%	-88%	-27%

NATURAL ATTENTUATION MONITORING

Verifying Progress

Expected Reductions – Verify Progress:

- Percent Reduction Calculations - LTNAM Reduction Worksheet
  - Average Reduction – sum of all individual COC percentage changes for all individual key wells during monitoring period divided by the total number of measurements.

Example Calculation:

{(20 - 18) / 20 * 100 +
(100 - 80) / 100 * 100 +
(10 - 15) / 10 * 100 +
(80 - 60) / 80 * 100}

All divided by 4 = ~1%

LONG TERM NATURAL ATTENUATION MONITORING REDUCTION WORKSHEET

Facility Name		Report Date	
Facility ID #		Baseline Sampling Date	

MW	Key Monitoring Well	Conc	Concentration of COC (must be >GCTL at baseline) in ug/L
COC	Contaminant of Concern (i.e., Benzene, Toluene,	GCTL	Groundwater Cleanup Target Level

				LTNAM Monthly Monitoring Period Concentrations									
MW	COC	GCTL	Baseline Conc	3	6	9	12	16	20	24	30	42	42 mo % Reduction
MW-1	Benzene	1	20	18	19	18	16	12	1	10	8	6	70%
MW-1	Toluene	40	100	80	75	50	52	40	42	40	45	42	58%
MW-3	Benzene	1	10	15	12	10	9	7	10	6	4	2	80%
MW-3	Toluene	40	80	60	65	70	60	40	42	35	40	30	63%
		Aggregate Reduction		1%	7%	18%	26%	45%	50%	52%	56%	68%	68%

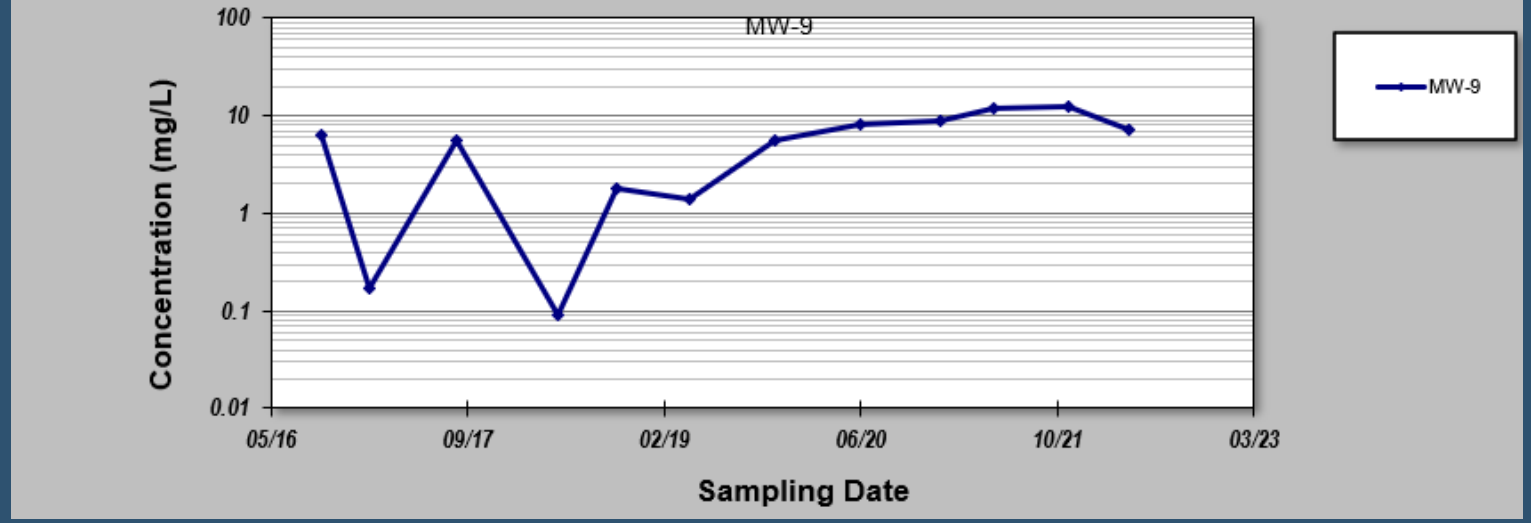
NATURAL ATTENTUATION MONITORING

Verifying Progress

Expected Reductions – Verify Progress:

- Trend Calculations:
  - Mann-Kendall – Plume Characterization.
    - Approved statistical method per subsection 62-780.610(2), F.A.C.
  - EPA – ProUCL.
  - Example site.

Coefficient of Variation:	0.73
Mann-Kendall Statistic (S):	34
Confidence Factor:	99.0%
Concentration Trend:	Increasing



NATURAL ATTENTUATION MONITORING

Verifying Progress

Timeframe for Achieving NFA (Example):

- At 42 months (3.5 years).
  - Trend increasing.
- At 45+ months (3.75+ years).
  - Site no longer meets criteria for NAM.

			Benzene	Toluene	Ethylbenzene	Ttl Xylenes
Sept 2012 Sys Start	MW-9	8/10/2012	94	260	230	450
		12/19/2012	0.23 U	0.20 U	0.20 U	0.22 U
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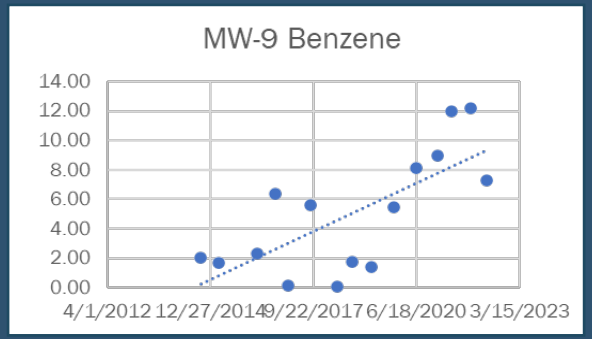

LONG TERM NATURAL ATTENUATION MONITORING REDUCTION WORKSHEET

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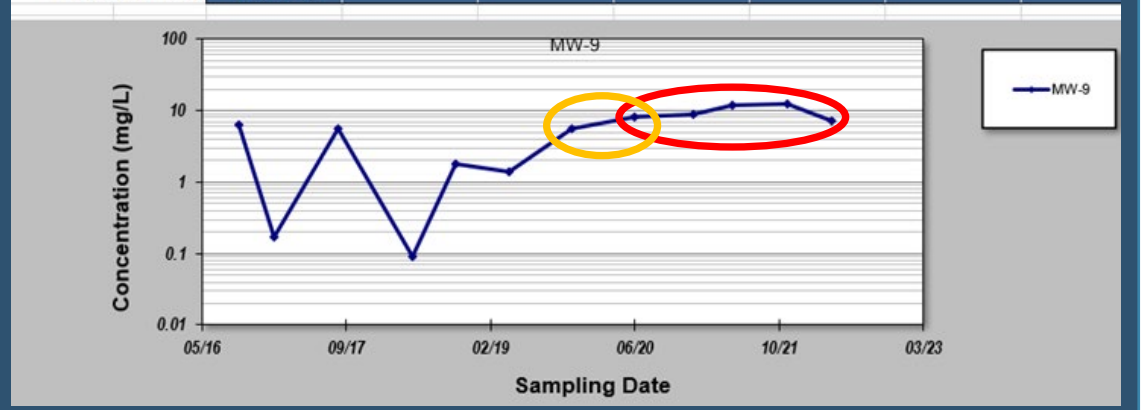
Coefficient of Variation:	0.73
Mann-Kendall Statistic (S):	34
Confidence Factor:	99.0%
Concentration Trend:	Increasing



NATURAL ATTENTUATION MONITORING

Verifying Progress

Timeframe for Achieving NFA:

- If significant reduction not being achieved at 42 months (3.5 years):
  - Recommend active remediation?
  - Is funding limiting return to active remediation?
  - Is alternative closure an acceptable option? For example:
    - Risk Management Option Level II (RMO II);
    - RMO III; or,
    - Low-Scored Site Initiative (LSSI) NFA.

NATURAL ATTENTUATION MONITORING

Verifying Progress

Timeframe for Achieving NFA:

- If significant reduction not being achieved at 42 months (3.5 years):
  - Recommend evaluation of Level 2 Criteria to continue NAM?
  - *Preliminarily* - Recommend monitoring for NAM parameters.
    - Are site-specific parameters limiting natural attenuation?
      - ✓ *Use to support recommended active remediation (enhancement).*
      - ✓ *Use to support continuing NAM under Level 2 Criteria.*

NATURAL ATTENTUATION MONITORING

Verifying Progress

NAM Parameters:

- 2018 Technical Protocol for Evaluating NA Parameters at Sites with Petroleum Contaminated Groundwater.
  - Guidance for evaluating effectiveness and progress of NAM using NAM parameters.
    - Laboratory: Nitrate and Nitrite, Manganese, Insoluble Iron and Dissolved Iron, Sulfate, Methane.
    - Field: Dissolved Oxygen, pH, Oxidation-Reduction Potential (ORP), Temperature.
    - Data may support enhancement(s) for natural attenuation.

NATURAL ATTENTUATION MONITORING

Continuing NAM

If NAM is Continuing – Cost Effective NAM Plan:

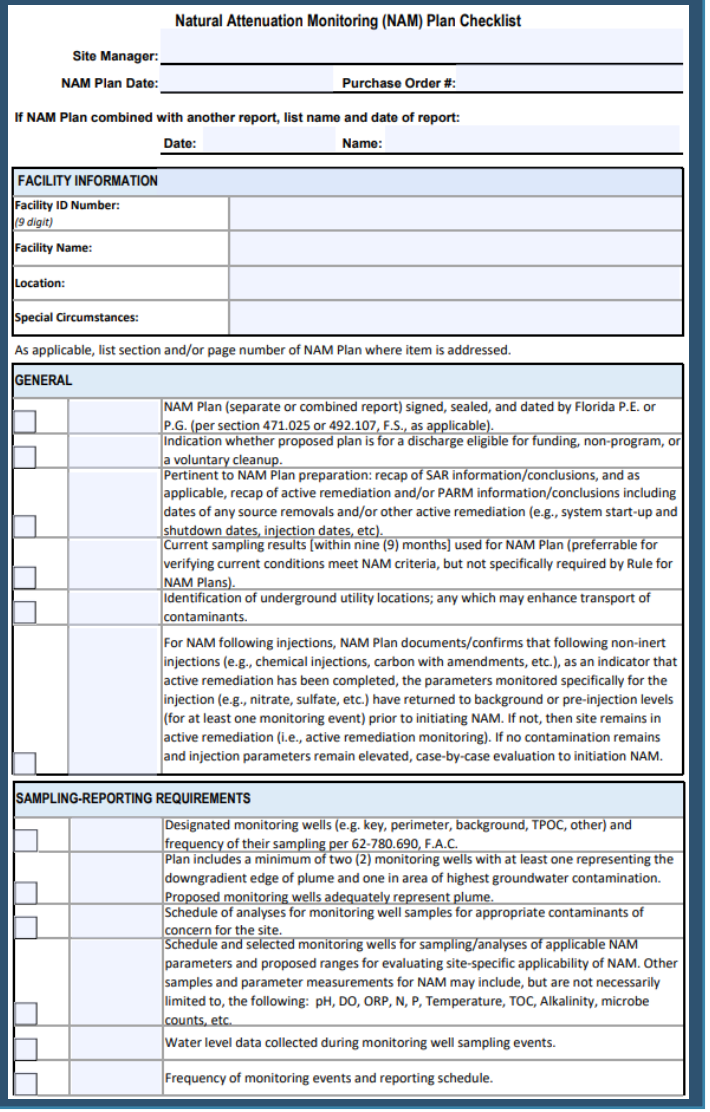
- Sampling Plan Reductions/Revisions.
  - Reduce frequency or remove select well(s) or parameters.
  - Change well(s).
- Changes proposed by Contractor.
  - DEP or Local Program (LP) Site Manager may recommend for consideration.
  - Anytime applicable.
  - Review with Professional.

NATURAL ATTENTUATION MONITORING

Continuing NAM

If NAM is Continuing – Cost-Effective NAM Plan:

- Maintain Minimum NAM.
  - Minimum of 2 wells (per Chapter 62-780, F.A.C.).
    - Downgradient edge of plume.
    - Highest contamination or source area.
  - Maintain data required for documenting achievement of closure goals.
  - Maintain data required for evaluating progress of NAM.
- Revise NAM Plan.
- Refer to NAM Plan Checklist for additional guidance.



Natural Attenuation Monitoring (NAM) Plan Checklist

Site Manager:

NAM Plan Date: Purchase Order #:

If NAM Plan combined with another report, list name and date of report:

Date: Name:

FACILITY INFORMATION	
Facility ID Number: *(9 digit)*	
Facility Name:	
Location:	
Special Circumstances:	

As applicable, list section and/or page number of NAM Plan where item is addressed.

GENERAL		
☐		NAM Plan (separate or combined report) signed, sealed, and dated by Florida P.E. or P.G. (per section 471.025 or 492.107, F.S., as applicable).
☐		Indication whether proposed plan is for a discharge eligible for funding, non-program, or a voluntary cleanup.
☐		Pertinent to NAM Plan preparation: recap of SAR information/conclusions, and as applicable, recap of active remediation and/or PARM information/conclusions including dates of any source removals and/or other active remediation (e.g., system start-up and shutdown dates, injection dates, etc).
☐		Current sampling results (within nine (9) months) used for NAM Plan (preferrable for verifying current conditions meet NAM criteria, but not specifically required by Rule for NAM Plans).
☐		Identification of underground utility locations; any which may enhance transport of contaminants.
☐		For NAM following injections, NAM Plan documents/confirms that following non-inert injections (e.g., chemical injections, carbon with amendments, etc.), as an indicator that active remediation has been completed, the parameters monitored specifically for the injection (e.g., nitrate, sulfate, etc.) have returned to background or pre-injection levels (for at least one monitoring event) prior to initiating NAM. If not, then site remains in active remediation (i.e., active remediation monitoring). If no contamination remains and injection parameters remain elevated, case-by-case evaluation to initiation NAM.

SAMPLING-REPORTING REQUIREMENTS		
☐		Designated monitoring wells (e.g. key, perimeter, background, TPOC, other) and frequency of their sampling per 62-780.690, F.A.C.
☐		Plan includes a minimum of two (2) monitoring wells with at least one representing the downgradient edge of plume and one in area of highest groundwater contamination. Proposed monitoring wells adequately represent plume.
☐		Schedule of analyses for monitoring well samples for appropriate contaminants of concern for the site.
☐		Schedule and selected monitoring wells for sampling/analyses of applicable NAM parameters and proposed ranges for evaluating site-specific applicability of NAM. Other samples and parameter measurements for NAM may include, but are not necessarily limited to, the following: pH, DO, ORP, N, P, Temperature, TOC, Alkalinity, microbe counts, etc.
☐		Water level data collected during monitoring well sampling events.
☐		Frequency of monitoring events and reporting schedule.

NATURAL ATTENTUATION MONITORING

Template NAM Report

Template NAM Report:

- Background.
  - Brief conclusions of Site Assessment, Active Remediation, PARM, NAM.
  - Dates any source removal completed and/or system shutdown.
- Recent NAM Activities.
- Evaluate Progress of NAM.
  - Criteria for NAM – Verify Maintained.
  - Comparison of data to Action Levels.
  - Comparison of data to expected reductions.
- Conclusions & Recommendations.
  - Anticipated timeframe for achieving NFA.

NATURAL ATTENTUATION MONITORING

Reviewing NAM Reports

Reviewing NAM Reports:

- Criteria for NAM – Verify Maintained.
  - Likely unchanged from initial review of NAM criteria:
    - Free Product?
    - Soil Contamination? If present, leaching?
    - COCs conducive to natural attenuation?

NATURAL ATTENTUATION MONITORING

Reviewing NAM Reports

Reviewing NAM Reports:

- Criteria for NAM – Verify Maintained.
  - Potential for change from initial review of NAM criteria:
    - Plume migrating horizontally? Vertically?
    - Data indicate a decreasing trend in contamination?
    - Site anticipated to achieve NFA via natural attenuation?
    - COCs below applicable CTLs at source property boundary?
      - ✓ If not, are TPOC(s) established and are COCs below applicable CTLs at TPOC(s)?
    - COCs below NADCs?
      - ✓ If not, is Level 2 NAM Plan approved and are Level 2 criteria met and maintained?

NATURAL ATTENTUATION MONITORING

Reviewing NAM Reports

Reviewing NAM Reports:

- Verify Progress:
  - Compare data to Action Levels.
    - If Action Level(s) exceeded, is recommended course of action provided?
  - Compare data to expected reductions.
    - Is significant reduction being achieved?

NATURAL ATTENTUATION MONITORING

Reviewing NAM Reports

Reviewing NAM Reports:

- Conclusions.
  - Is site anticipated to achieve agreed upon closure goal (e.g., RMO I, RMO II, RMO III, LSSI NFA) by natural attenuation?
    - Is estimated timeframe for achieving NFA maintained? lengthening?
  - If NAM criteria not maintained, is recommended course of action provided?

- Refer to NAM Report Checklist for additional guidance.

NATURAL ATTENTUATION MONITORING

Summary

Summary:

- Florida Statute and Florida Administrative Code Review.
- Criteria for NAM.
- Verifying Progress.
  - Timeframe for achieving NFA.
    - i.e., achieve agreed upon closure goal (e.g., RMO I, II, or III; or LSSI NFA).
  - Action Levels.
  - Expected Reductions.
  - NAM Parameters.
- If continuing NAM - Cost Effective NAM.
- Reviewing NAM Reports.

If NAM is not progressing – return to active remediation - Achieve NFA.

NATURAL ATTENTUATION MONITORING

Additional NAM Guidance

Additional NAM Guidance:

- 1998 BPSS-11 NAM Procedures.
  - Uses Level 1 and Level 2 terminology.
- 2018 Technical Protocol for Evaluating NA Parameters at Sites with Petroleum Contaminated Groundwater.
  - Guidance for evaluating effectiveness and progress of NAM using NAM parameters.
- 2022 Revised Procedures for Implementation of the NAM in PRP (Supersedes February 1, 2011, Procedures).
  - Uses Level 1 and Level 2 terminology.

QUESTIONS?

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