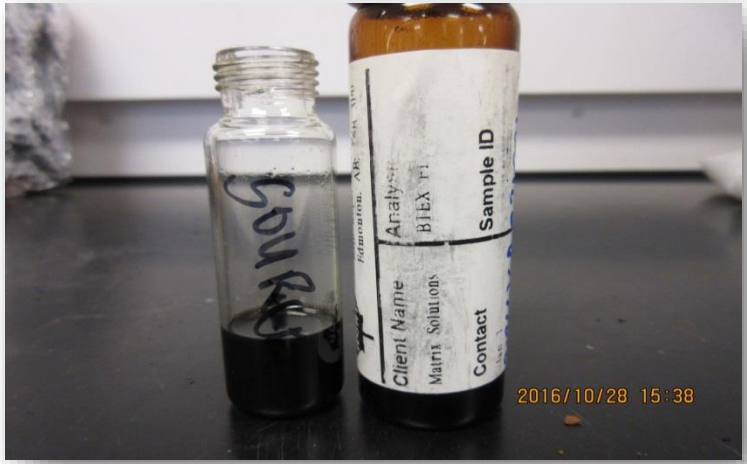
Augmented Bioremediation of PHC Fractions F2 and F3

Evaluation of Bioremediation of Condensate-Impacted Peat and Mineral Soil

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

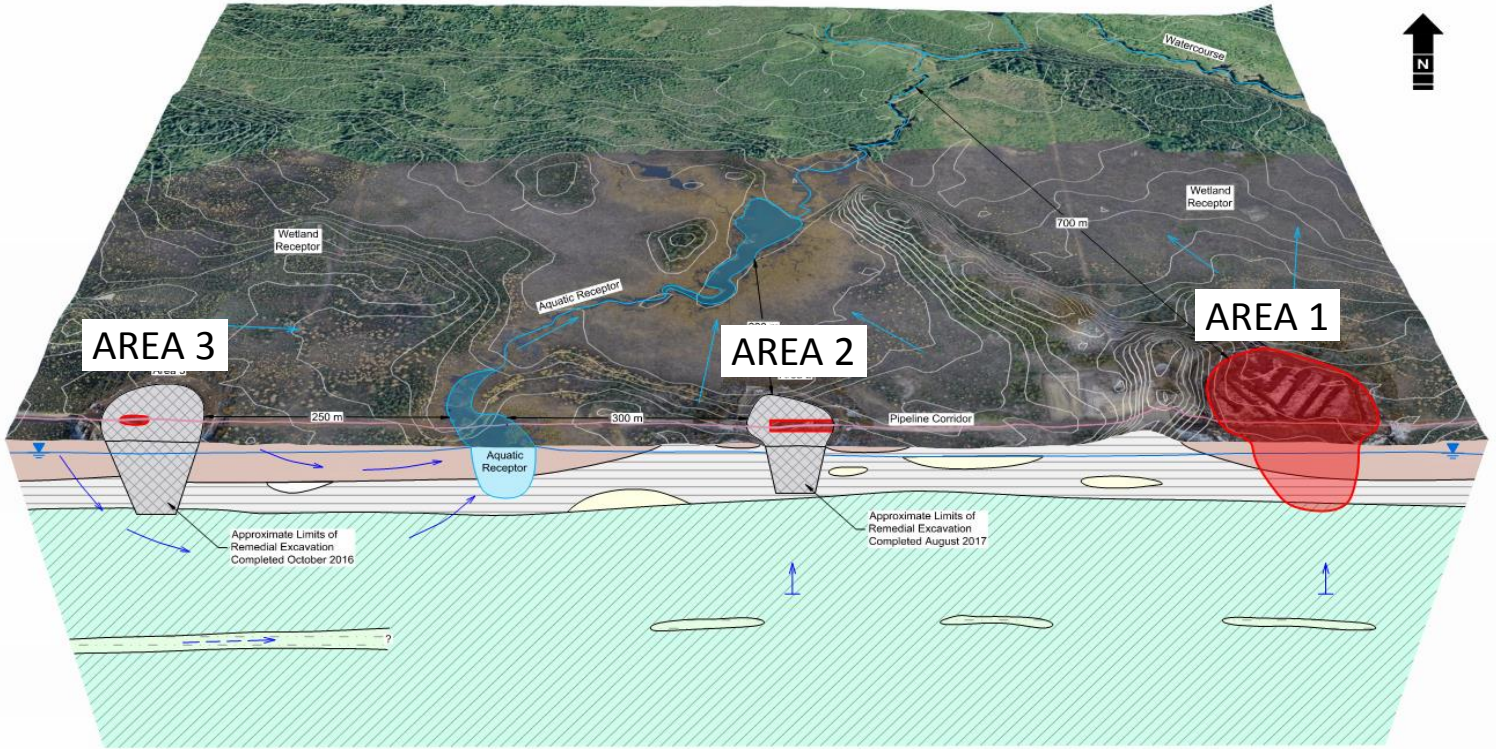
Outline

- Introduction
- Approach
- Methods
- Results
- Conclusions

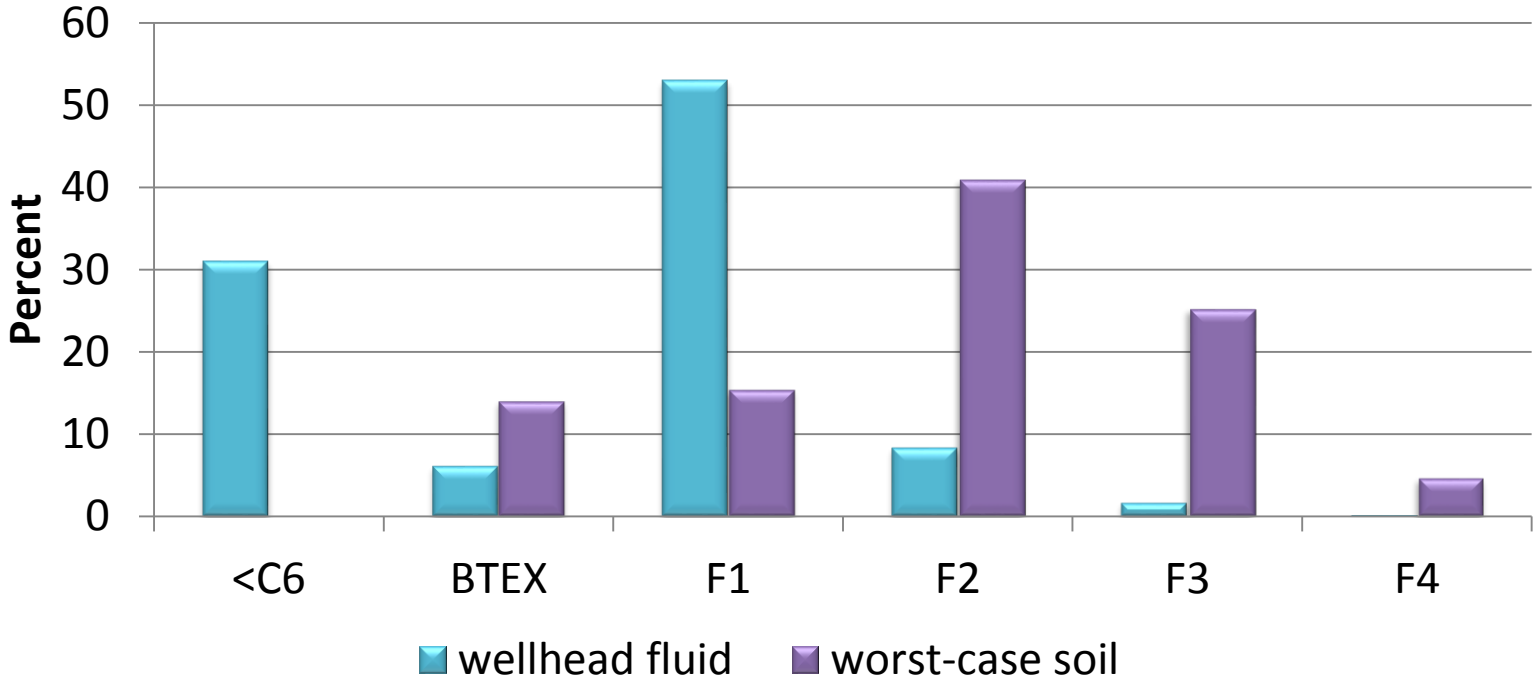


INTRODUCTION

Release Areas



Petroleum Hydrocarbon Composition



APPROACH

Remediation Selection

Murphy Workshop Panel Decision Process Considerations

Remediation Pre-Startup

1. BIOAUGMENTATION

- no augmentation
- moisture control
- fertilizer amendments
- oxygen delivery chemicals
- dry powder microbes
- soluble spray-on microbes

2. AREA 3 REMEDIATION TRIAL

- correlate findings
- bench scale lab testing

3. LAB SET-UP AND APPROACH

- analytical regime

Initial Average F2 and F3 Starting Concentrations
PEAT SOIL

Impacted Sample Set	Ave PHC F2 Concentration (mg/kg)	Ave PHC F3 Concentration (mg/kg)
Slightly (A)	494	1,102
Moderately (B)	2,054	3,003
Heavily (C)	6,152	7,217

Initial Average F2 and F3 Starting Concentrations

CLAY SOIL

Impacted Sample Set	Ave PHC F2 Concentration (mg/kg)	Ave PHC F3 Concentration (mg/kg)
Slightly (A)	382	523
Moderately (B)	1,521	1,777
Heavily (C)	3,268	3,204

METHODS

Methods

- Peat and clay soil matrices were prepared at slightly, moderately, and heavily impacted PHC concentrations
- Amendments were added to all but the control samples
- Baseline analyses in triplicate on Day 0
- Mixed on Days 7, 14
- Amendments re-applied on Day 90

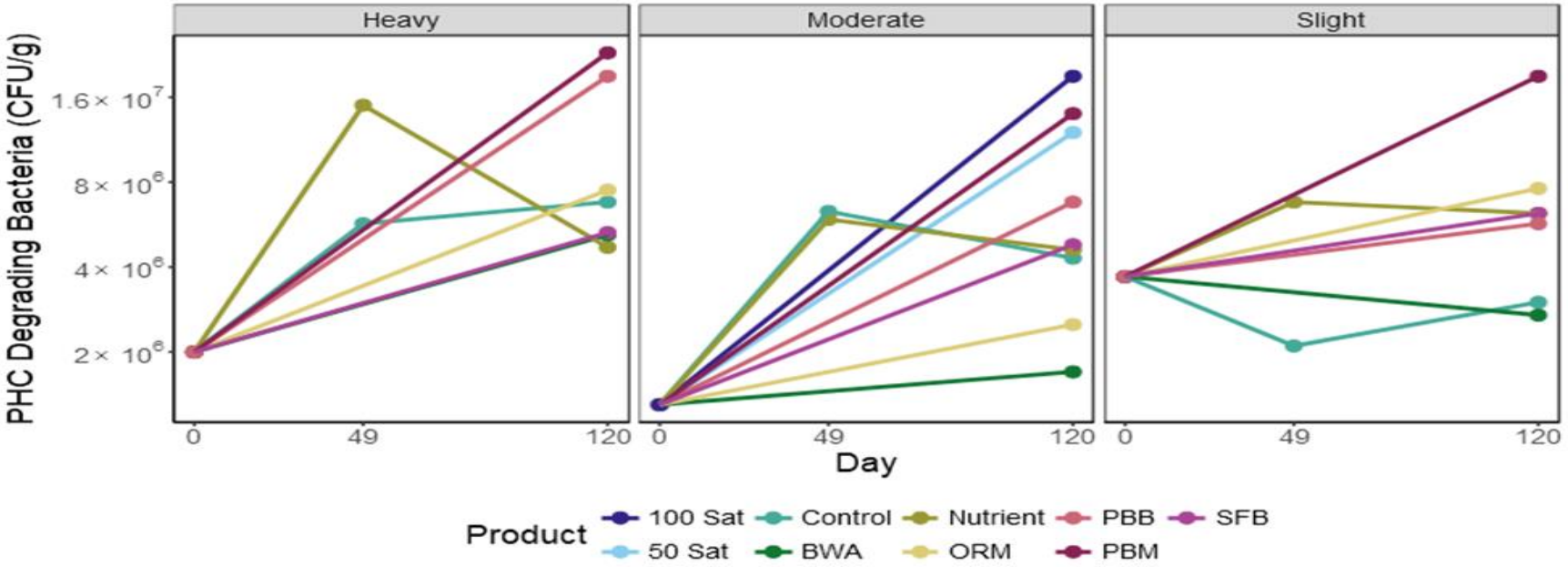
- Laboratory analyses on Days 0, 7, 14, 21, 33, 49, 63, 96, 104, 120

Amendment Key

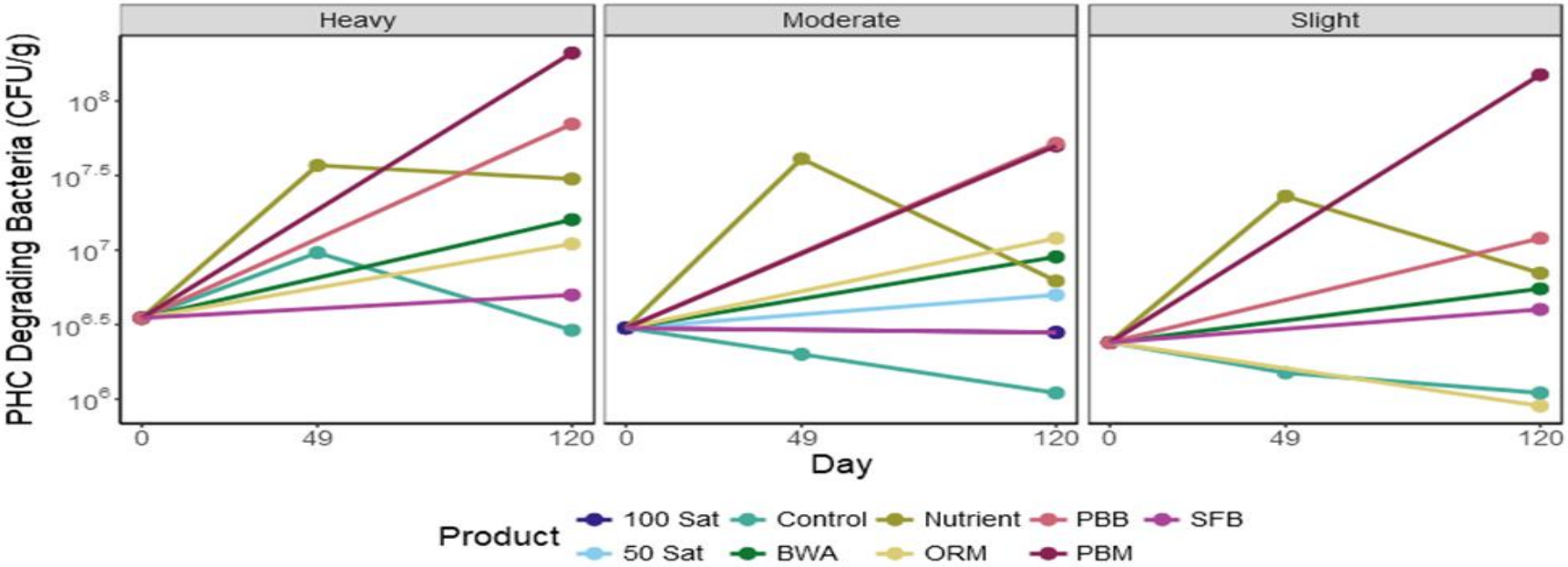
Product ID	Description
Nutrient	Fertilizer (urea and mono-ammonium phosphate)
ORM	Chemical oxygen release material
BWA	Nutrient and surfactant liquid
SFB	Liquid nutrients and bacteria
PBM	Powder applied microbes applied via liquid
PBB	Powder applied microbes applied dry

RESULTS

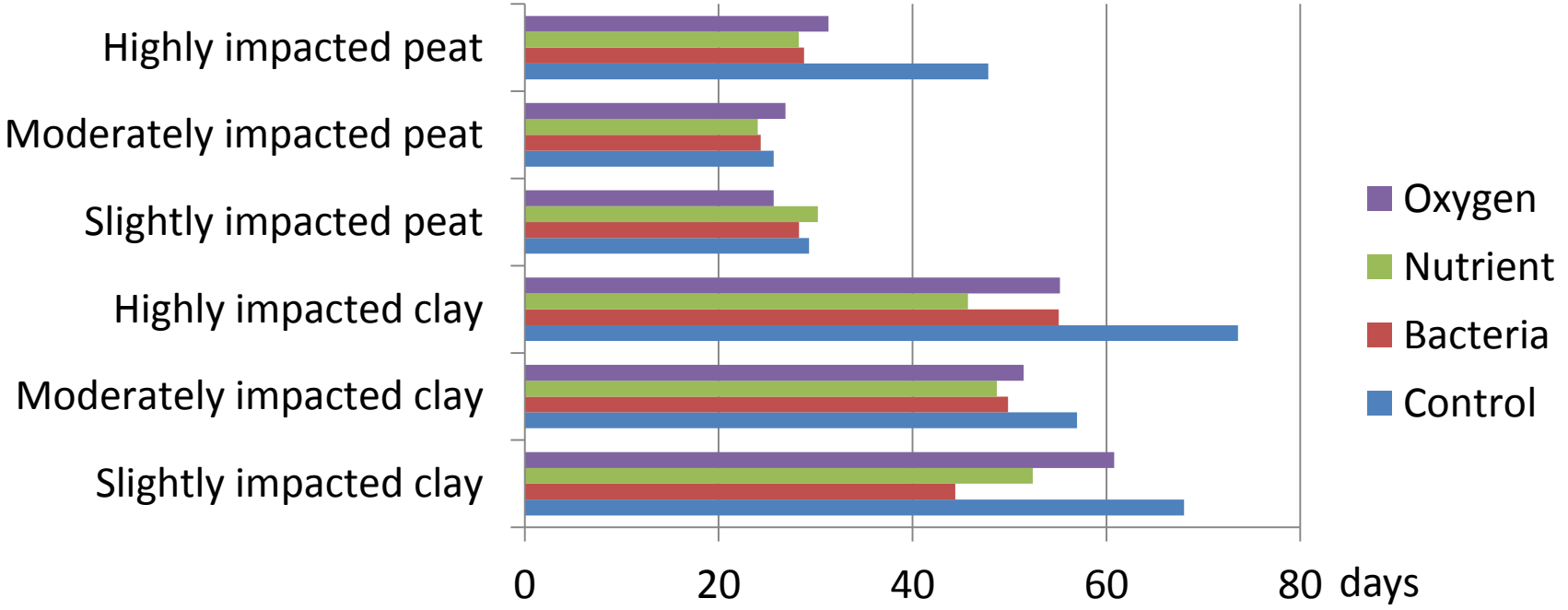
Results: Peat Microbiology



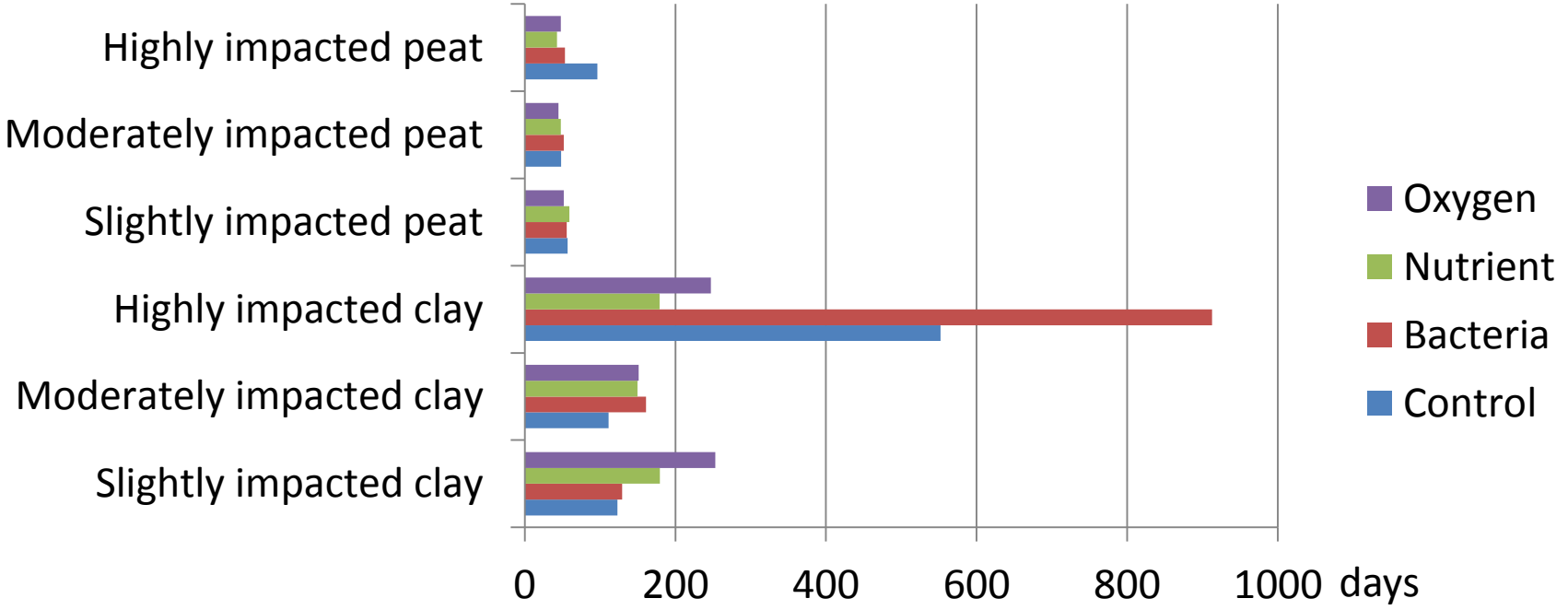
Results: Clay Microbiology



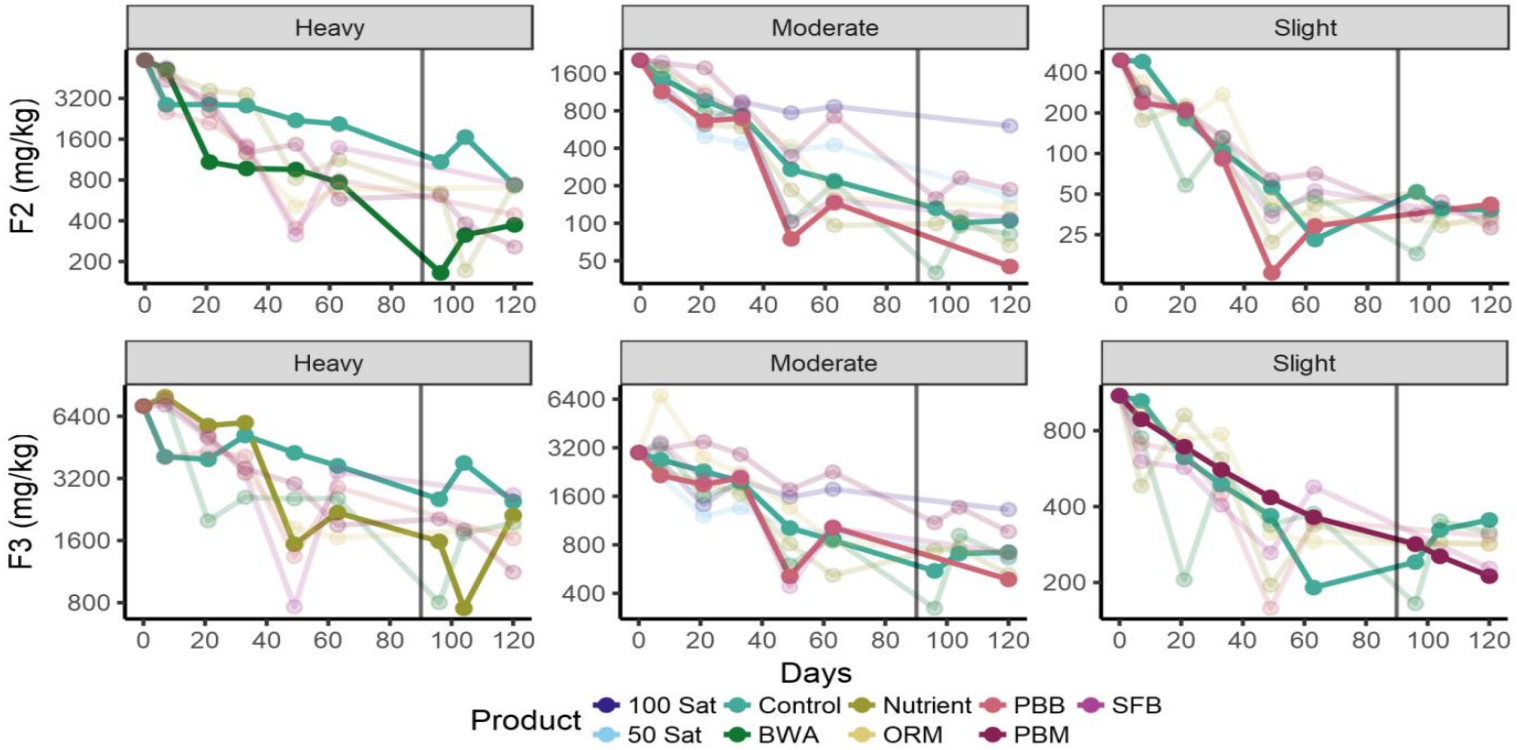
Results: F2 Degradation Half-Lives



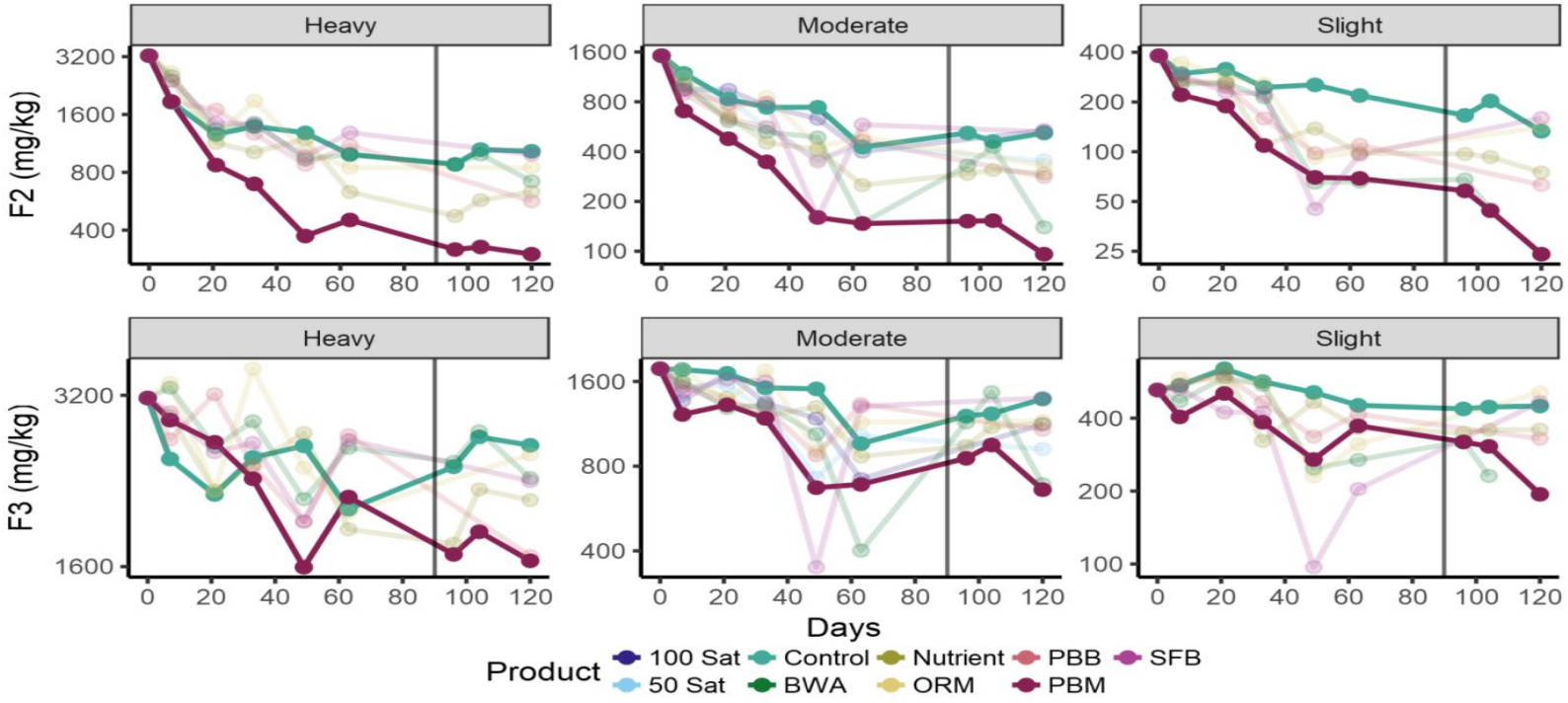
Results: F3 Degradation Half-Lives



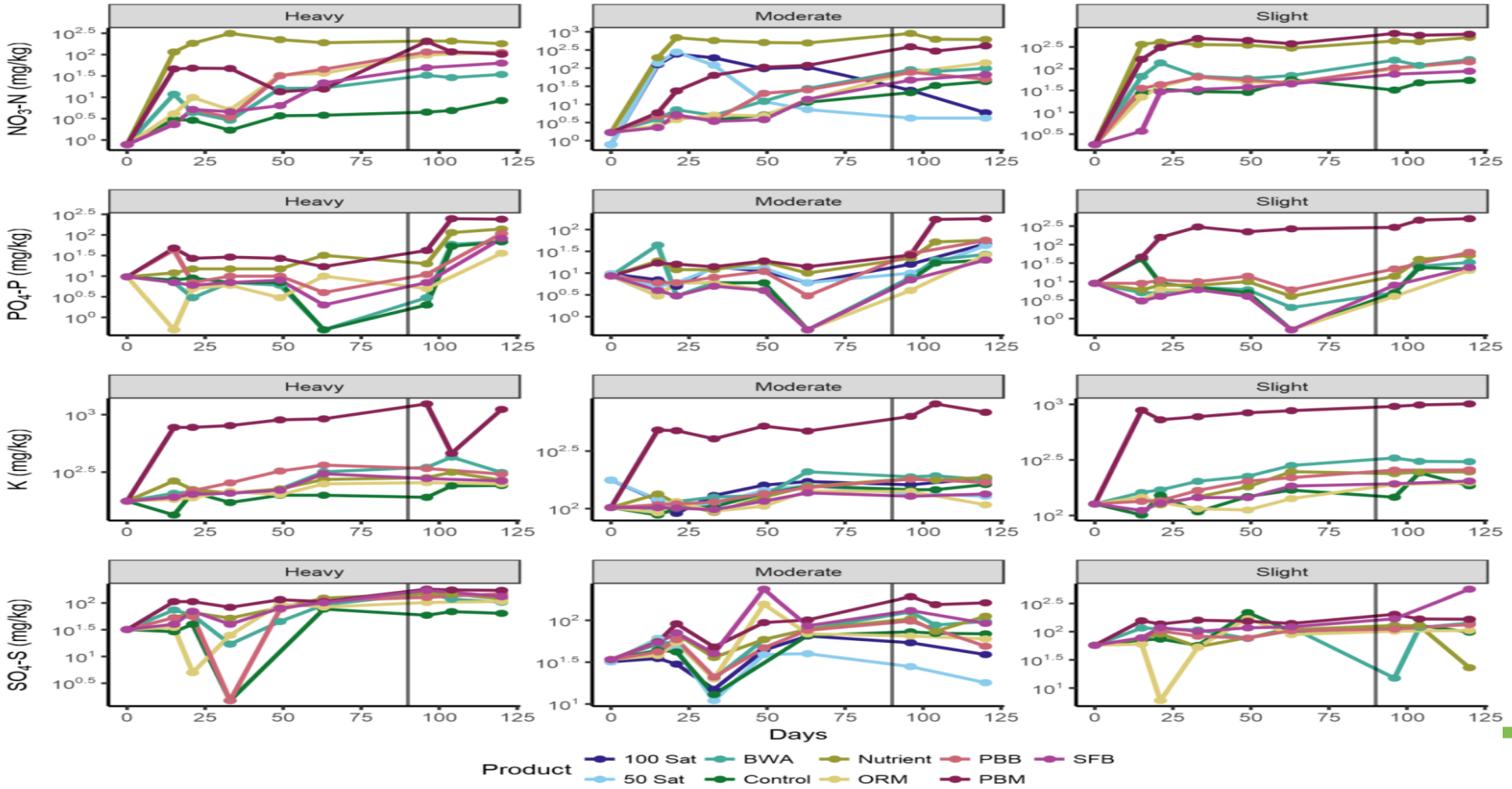
F2 and F3 Concentrations in Impacted Peat



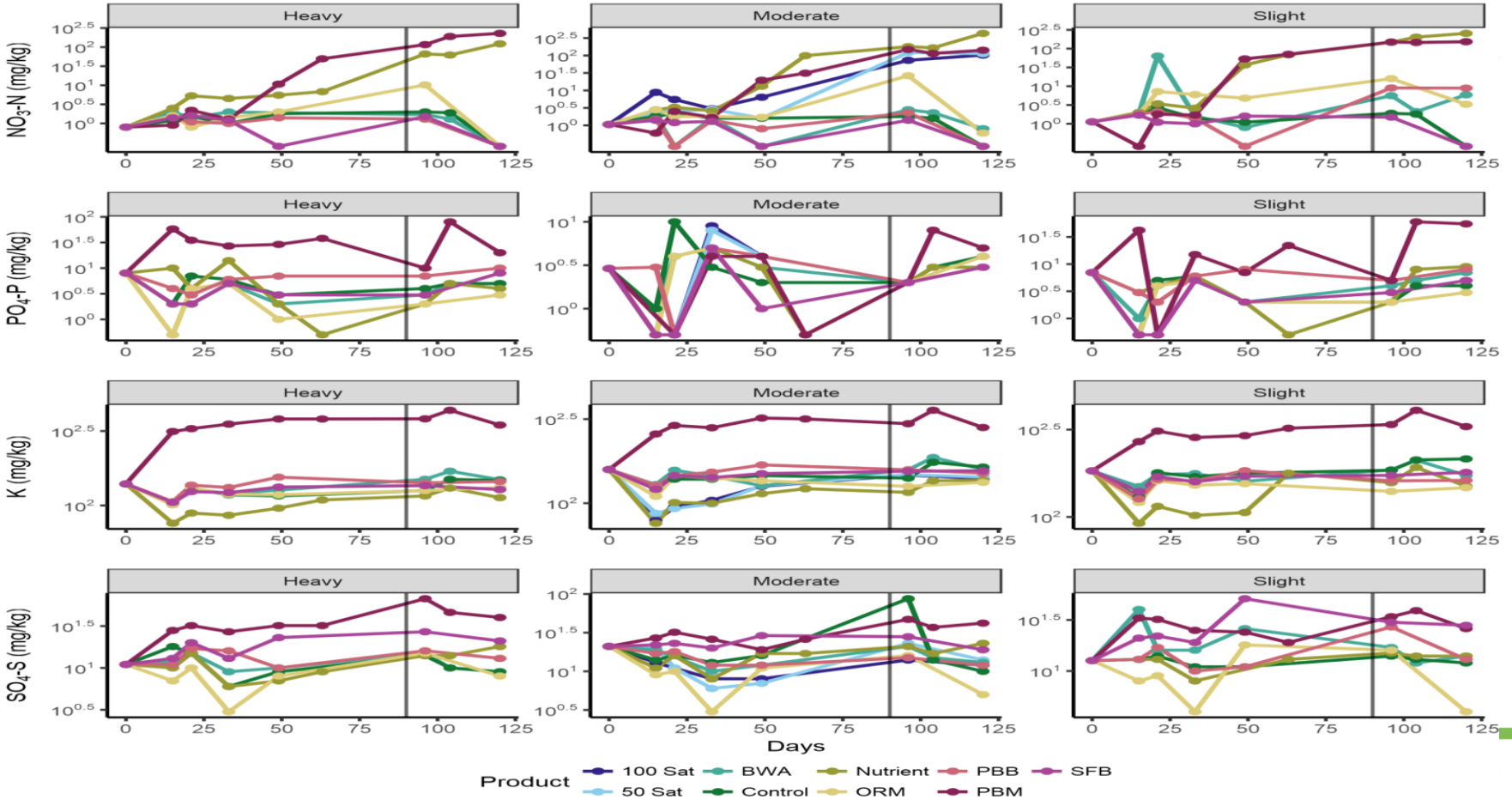
F2 and F3 Concentrations in Impacted Clay



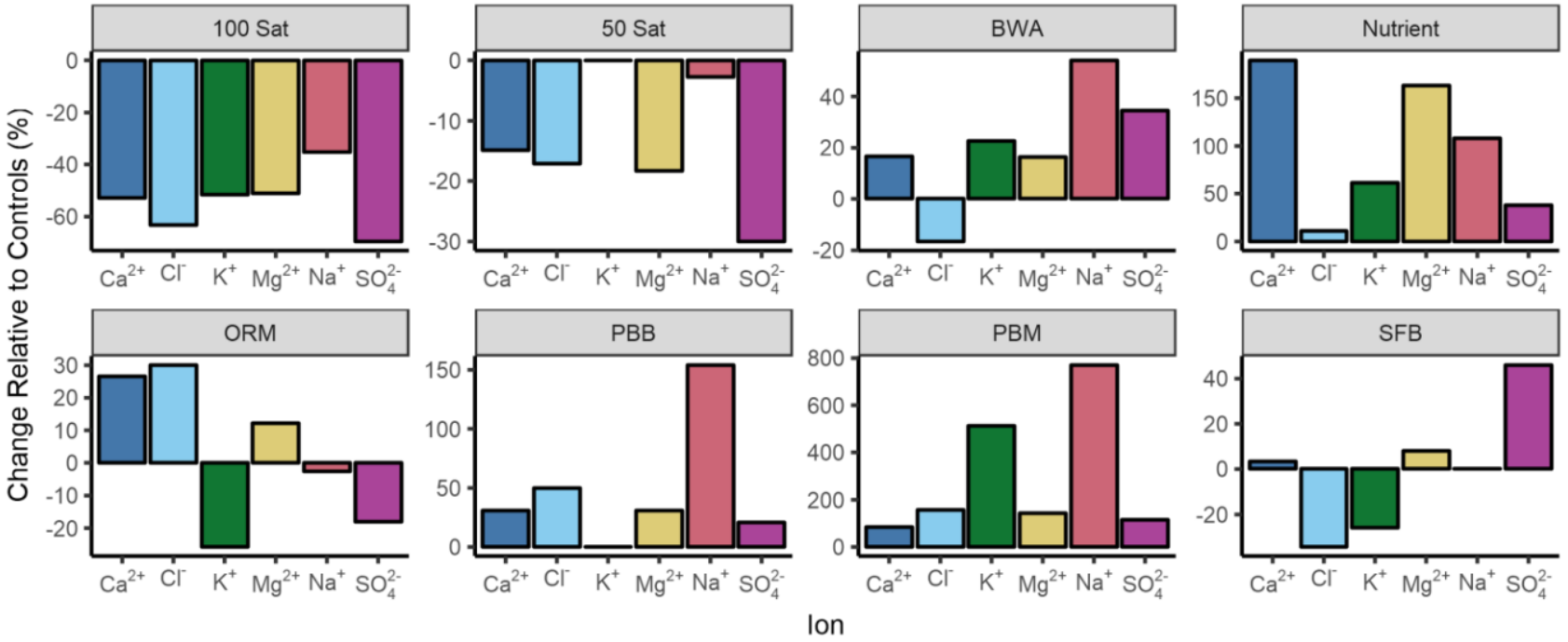
Peat Nutrient Concentrations



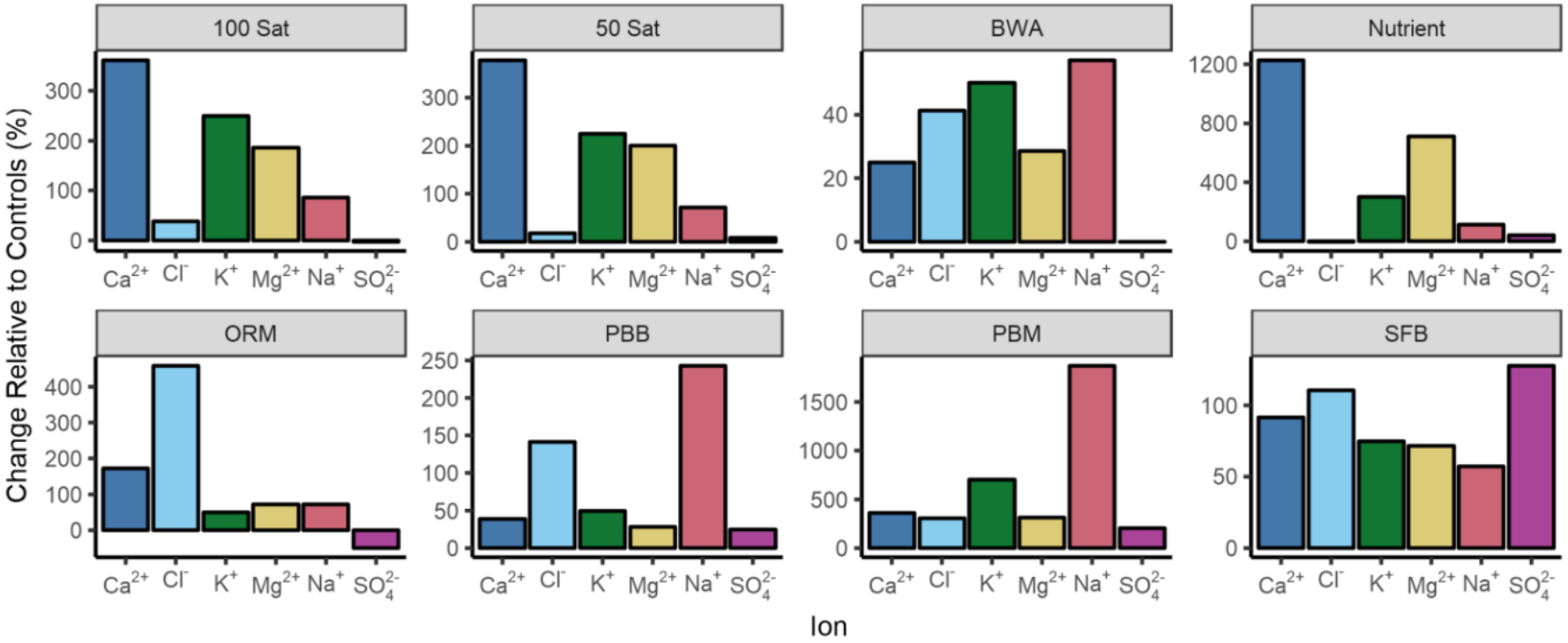
Clay Nutrient Concentrations



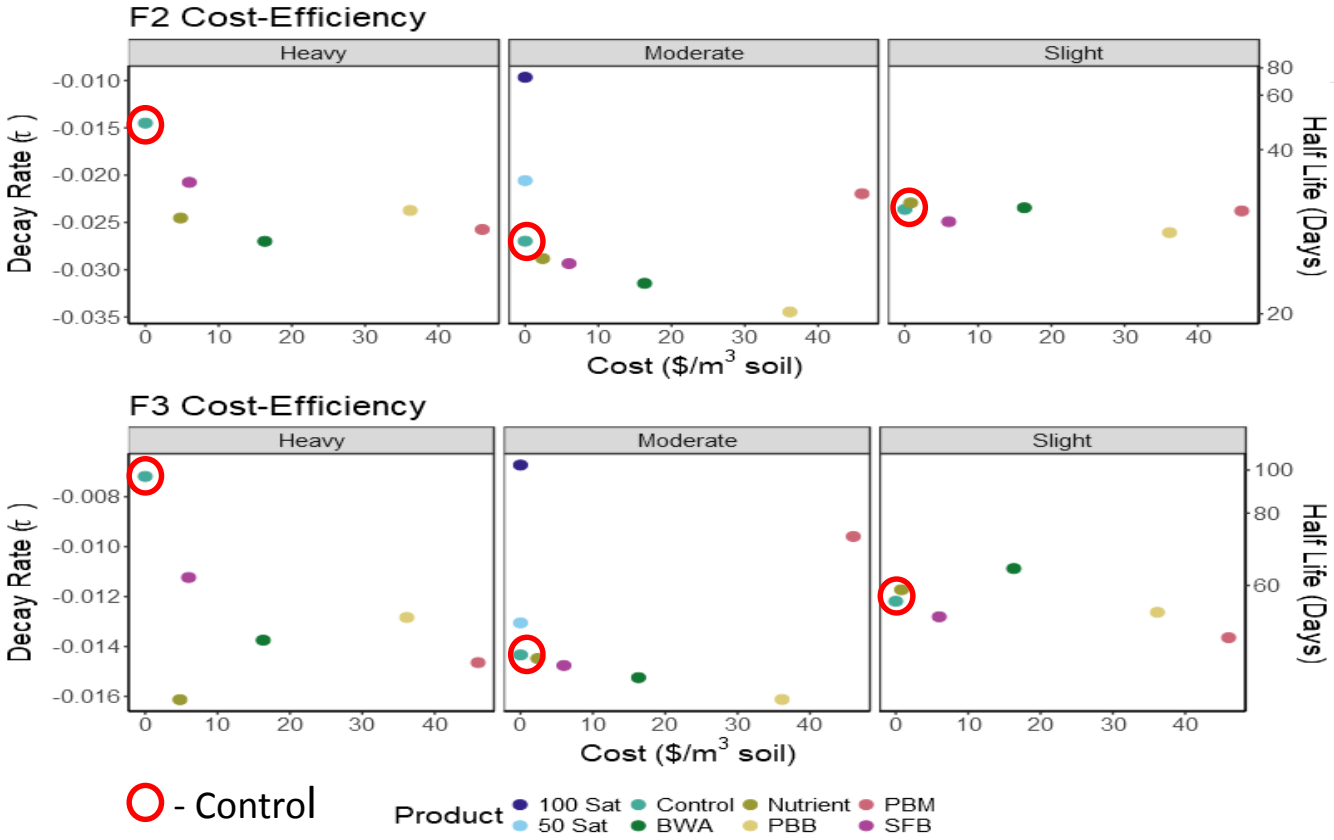
Salinity of Peat Samples at Day 120, Relative to Controls



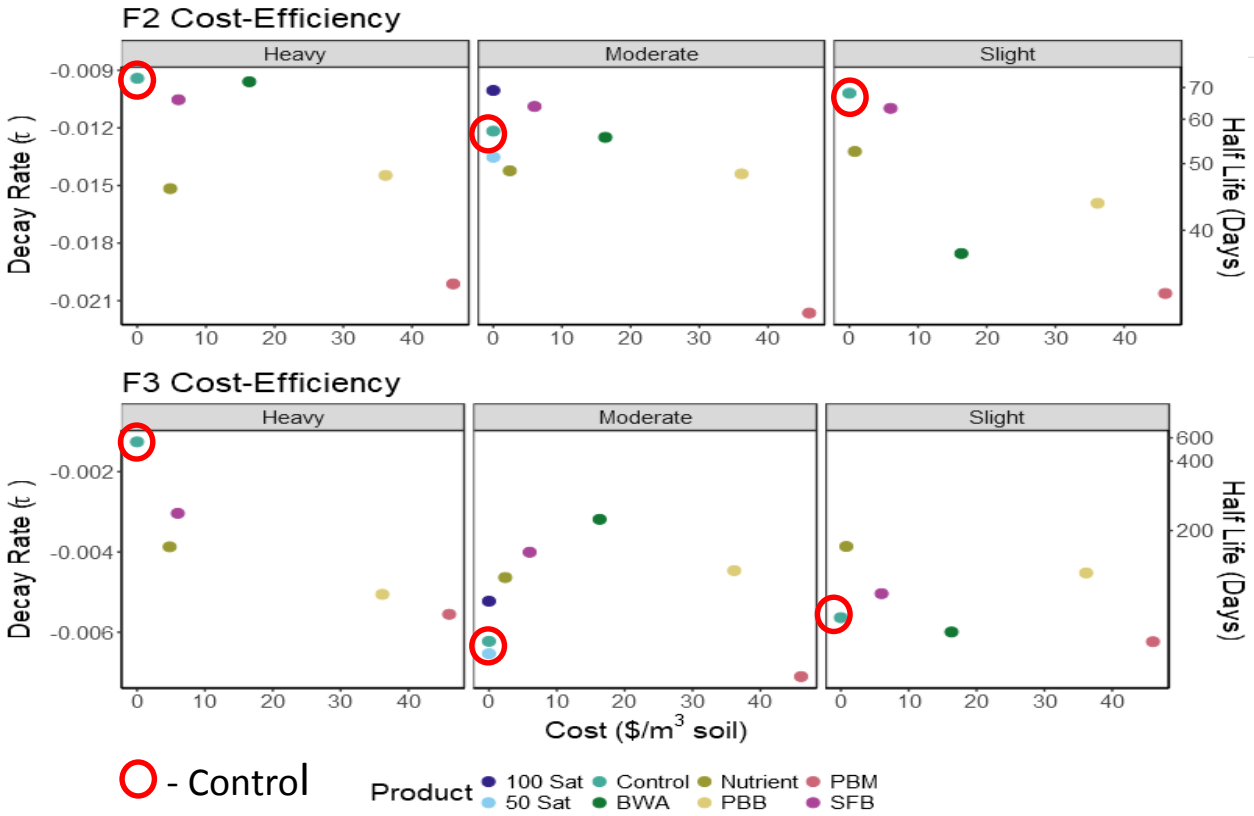
Salinity of Clay Samples at Day 120, Relative to Controls



Cost-efficiency Graphs for Impacted Peat Soil



Cost-efficiency Graphs for Impacted Clay Soil



CONCLUSIONS

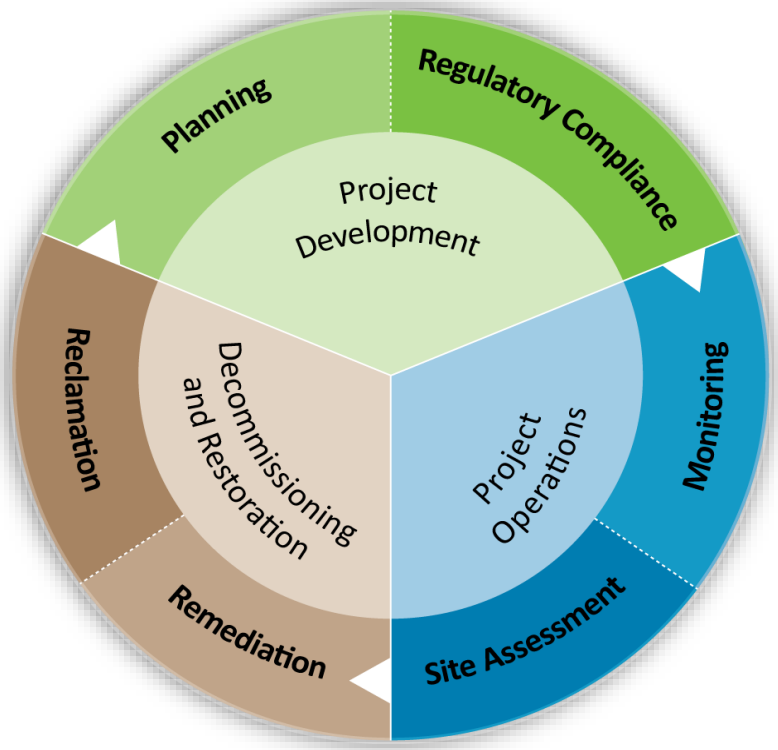
Conclusions

- Both amendment and control plots performed well in biodegrading PHC fractions F2 and F3, as well as PAHs
  - ideal laboratory conditions
  - high starting population of hydrocarbon-degrading bacteria
- Half-lives were longer in clay than in peat
- Nutrient and bacteria amendments did not significantly increase the rate of biodegradation, although final end concentrations seemed to be lower
- Too much moisture appeared to impede biodegradation

Conclusions

- Overall, it was concluded that natural bioremediation without amendments would be effective
  - with sufficiently high microbial populations at the start
  - with sufficient nutrients
- Nutrient addition is relatively inexpensive and appeared to have a positive influence on end concentrations
  - aim for carbon:nitrogen:phosphorus ratio of 100:10:1
  - apply nitrogen in small, periodic doses to avoid elevating nitrate concentrations in groundwater
- Starting F2 concentration at just over 1,000 mg/kg and F3 at well under 1,000 mg/kg to meet criteria. Peat and clay performed differently.

Thank You



www.matrix-solutions.com

jbanks@matrix-solutions.com