



# Plasma Pulse Technology (PPT)

A Reservoir Treatment Technology for  
Enhanced Hydrocarbon Recovery

# Enhanced Recovery Goals

- Increase production and improve recovery factor
- With minimal capital outlay
- Without damaging the wellbore
- In an environmentally friendly way
- With a proven technology

# Plasma Pulse Technology Offering

- Increased recovery of oil in place through treatment of the entire reservoir leading to increased production through enhanced permeability & reduced oil viscosity
- A variety of payment models available which are much less than most other forms of EOR
- Cleans perforations and aids in reduction of skin factor with no damage to casing or cement
- Treatment uses no water or chemicals thus no need for EPA permitting
- Proven technology – Over 350 wells successfully treated globally

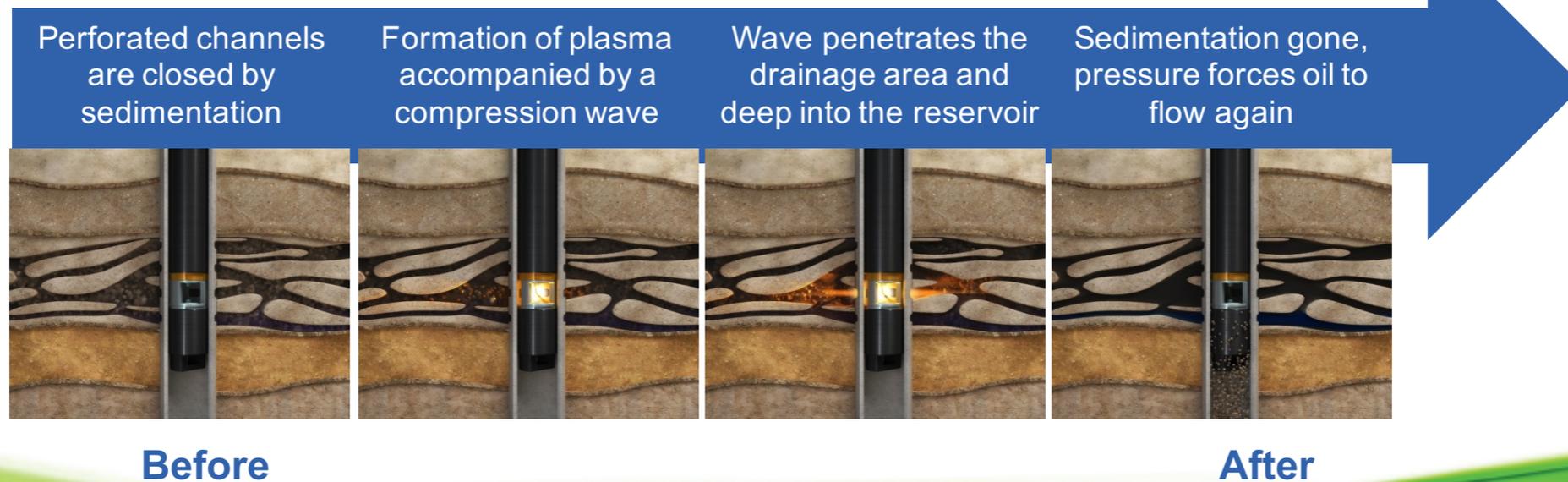
# How PPT Works

*Plasma Pulse: A powerful instantaneous discharge of super ionized energy per pulse propagating a series of shock waves*

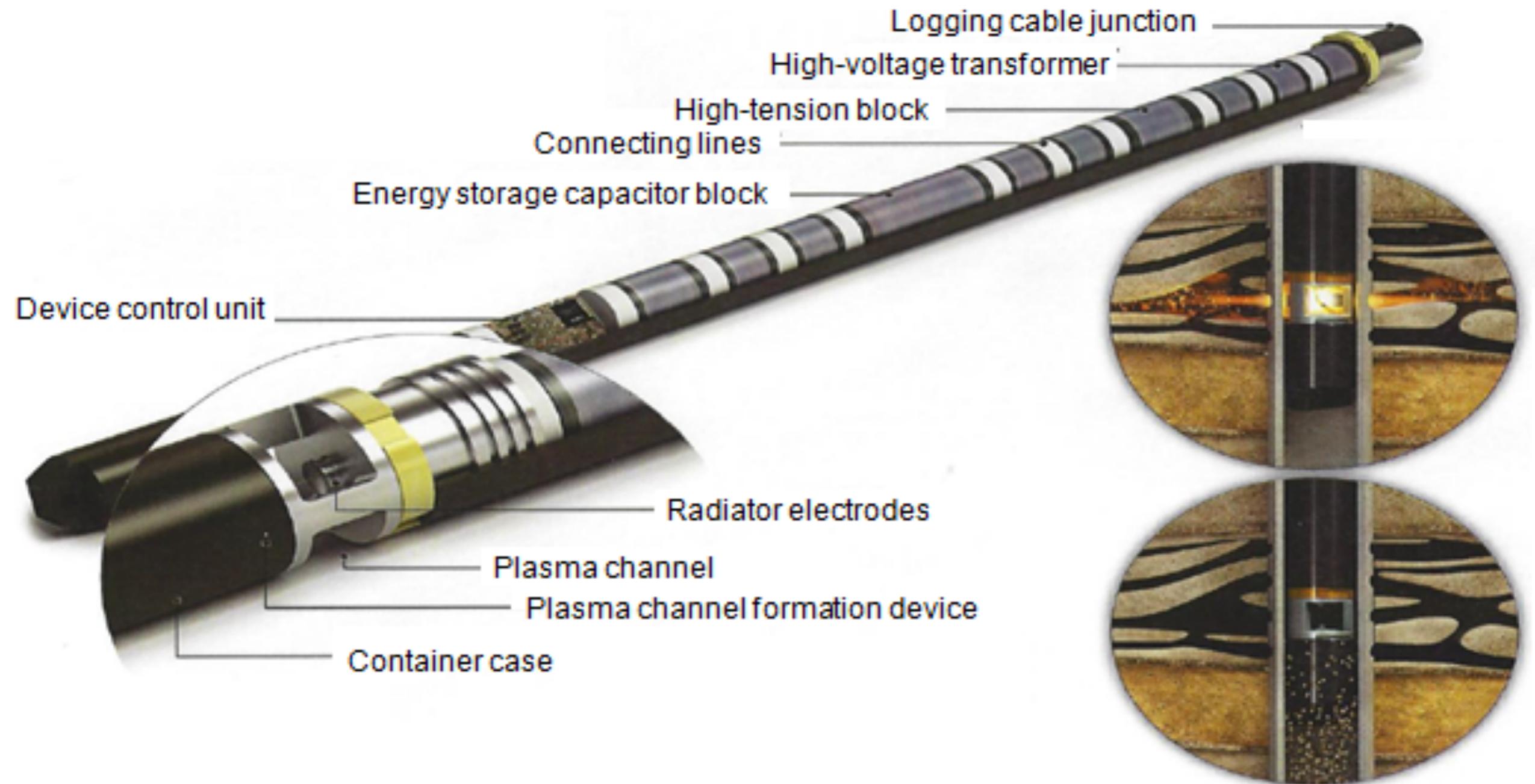
- Plasma Generator ionizes a metal filament creating a coronal discharge. This powerful discharge emits a series of non-linear acoustic waves that resonate throughout the reservoir
- The propagation of these waves excites the fluid molecules and the natural resonance in the reservoir
- The high frequency waves open the perforations and clean the near wellbore skin
- The lower frequency waves travel deep into the reservoir increasing its natural resonance opening pore spaces and reducing the oil viscosity

# Increased Production

- Increased Permeability through opening of pore spaces and the creation of micro fractures
- Lower Oil Viscosity up to 20%
- Perforation tunnel and Skin clean up
- Oil molecules wetting rock are released
- Effects of treatment last up to one year



# Plasma Pulse Generator



The treatment duration and number of pulses stimulating the formation are determined by the OIP, production interval parameters and geological characteristics of the deposit

# Tool Specifications



- Presently only for vertical wells (< 50° deviation), Horizontal system coming in 2016
- Sizes Available:
  - 4.02" (102 mm) OD, 9.02 ft.(2750 mm) length available now
  - 3.50" (89 mm) OD, 9.4 ft. (2865 mm) length final testing in ongoing
  - 2.00" (64 mm) OD, 9.96 ft. (3036 mm) length available Q1 2016
- Maximum BH Temperature = 203° F (95° C)
- Maximum BH Pressure = 5800 psi (40000 kPa)
- Minimum 50 ft. fluid head required above tool during treatment
- Minimum 4 SPF (13 SPM) perforations
- Wireline requirements: Standard US/Canada



Simulated blocked perforated casing target before pulsing



Target post pulsing

Unsupported cement is not debonded off test target during plasma pulsing

The perforations become unplugged and open to allow fluid entry post pulsing

# Well Selection and Operational Procedure

- Operator provides all required well data including historical production, past remedial and stimulation, well logs, fluid level, perforation interval, PLT, BHT, BHP, etc.
- Well parameters evaluated by Novas Energy Team
- If deemed candidate a Treatment Plan is prepared & agreed upon
- Treatment is scheduled preferably in coordination with scheduled well maintenance
- Operator prepares well for treatment by removing pump and pulling completion
- Arrival on site with wireline, wireline crew, Novas Energy tools and crew
- Administer treatment per plan
- Perform post-treatment evaluation including production data sharing (oil, gas, condensate, water)
- Implement ongoing field treatment plan

# Well Specific Treatment Plan

## Scope of Work Planning

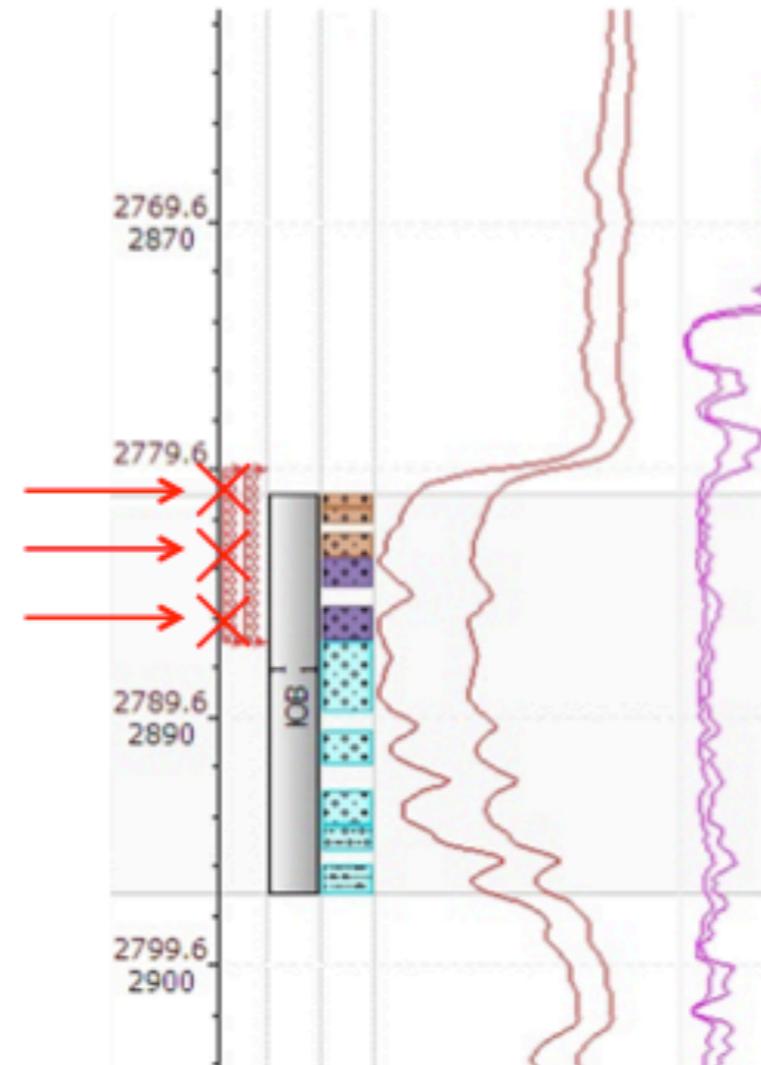
1. The number of spots to be treated depends on:

- Type of reservoir
- Capacity of productive interval
- Rock saturation properties
- Influx profile
- Oil-water contact
- Gas-oil contact

2. The required number of pulses is affected by:

- Perforation density
- Rock permeability
- Existing production casing
- Cement properties
- Influx profile
- Rock saturation properties

3. Forecast of potential production is based on math simulation models and operating time statistics



# Case Studies



# Select US Treatments

Well Location	Formation Type	Before PPT	After PPT	% Increase
		Oil (bpd)	Oil (bpd)	
Caddo Co, LA	Limestone	1	3	300%
Kay Co, OK	Limestone	5	12	240%
Creek Co, OK	Sandstone	1.5	5.5	367%
Creek Co, OK	Sandstone	1	57	5700%
Creek Co, OK	Sandstone	1	44	4400%
Creek Co, OK	Sandstone	1	20	2000%
Sedgwick Co, KS	Limestone	2.4	4.8	200%
Natrona Co, WY	Sandstone	5	22	440%
Natrona Co, WY	Sandstone	1	8	800%
Safford Co, KS	Limestone	2	40	2000%
SW CO	Shale	25	80 initial, 106 now	424%

# Results from Oil Producing Wells

Oil Field	Depth (ft)	Before Novas Treatment		After Novas Treatment		Oil, Bpd Increase	% Increase
		Oil Bpd	% Watercut	Oil Bpd	% Watercut		
Hvojnoe	9364	0.00		119.20	15	119.2	100
Shkapovskoe	N/A	2.24	43	17.88	45	15.6	700
Fedorovskoe	N/A	5.22	12.5	19.37	18.7	14.2	271
Shkapovskoe	N/A	5.96	97	12.67	96.6	6.7	113
Vasilovskoe	N/A	5.96	20	38.00	21.5	32.0	538
Pashninskoe	4756	6.71	79	14.90	61	8.2	122
Sovetskoe	5904	7.45	75	29.80	69	22.4	300
Djusushevskoe	11808	14.90	85	81.95	70	67.1	450
Krapivinskoe	9315	29.80	66	89.40	77	59.6	200
Severnoye	7052	33.53	2	88.66	2	55.1	164
Tevlinskoe	9184	43.96	74	104.30	39	60.3	137
Tajlakovskoe	10922	52.15	18	163.90	2	111.8	214
Pervomajskoe	9610	201.15	20	305.45	20	104.3	52

# Injection Well Results

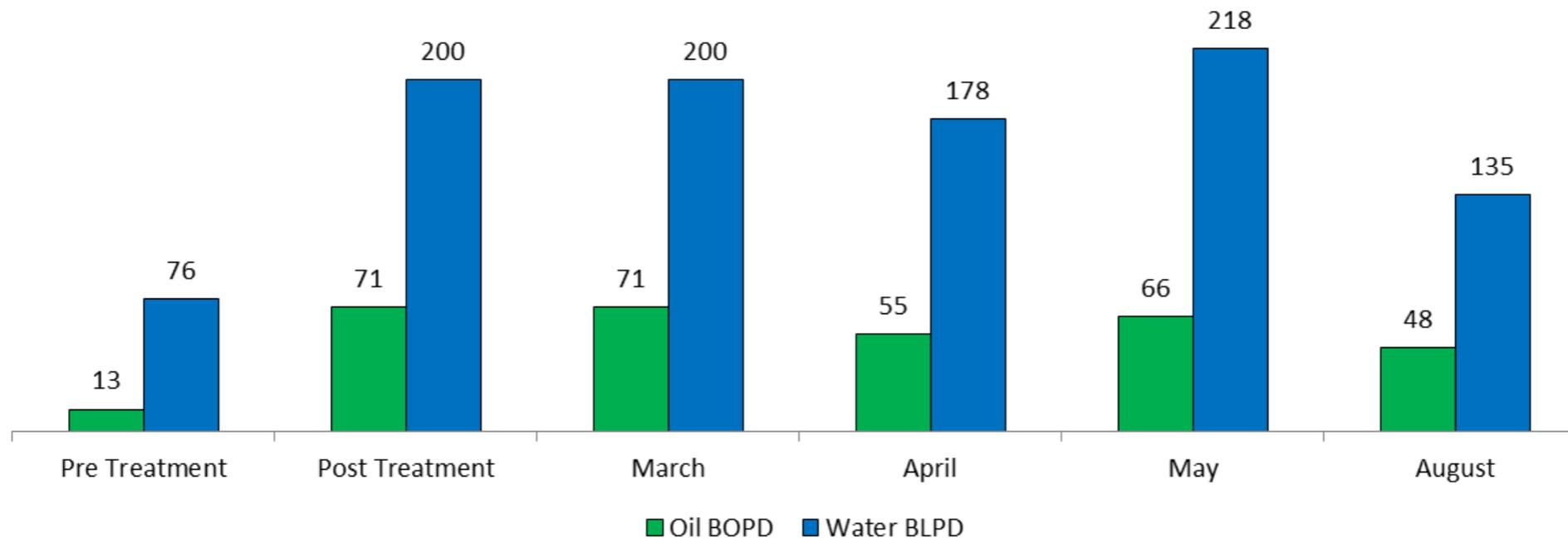
Oil Field	Bbls/Day Before	Bbls/Day After	Increase	% Increase
Lomovoe	119	728	609	511
Poludennoe	314	942	628	200
Sutorminskoe	157	1080	923	588
Sutorminskoe	63	345	282	450
Tajlakovskoe	31	376	345	1100
Arlanskoe	31	138	107	340
Turchaninovskoe	125	546	421	335
Muravlenkovskoe	1727	4396	2669	155

# Increase in the Well Production Rate

DFL before treatment – 2250  
DFL after treatment – 1817  
Formation – D3fm  
Operating capacity – 8,6 m  
PI before treatment – 0,09  
PI after treatment – 0,33

**Well #:** C-7  
**Oil field:** Russia, Dyusushevskoye  
LLC Polar Lights Company  
**Reservoir:** Carbonate  
**Well Type:** Production Well

DFL = Dynamic Fluid Level, PI = Productivity Index

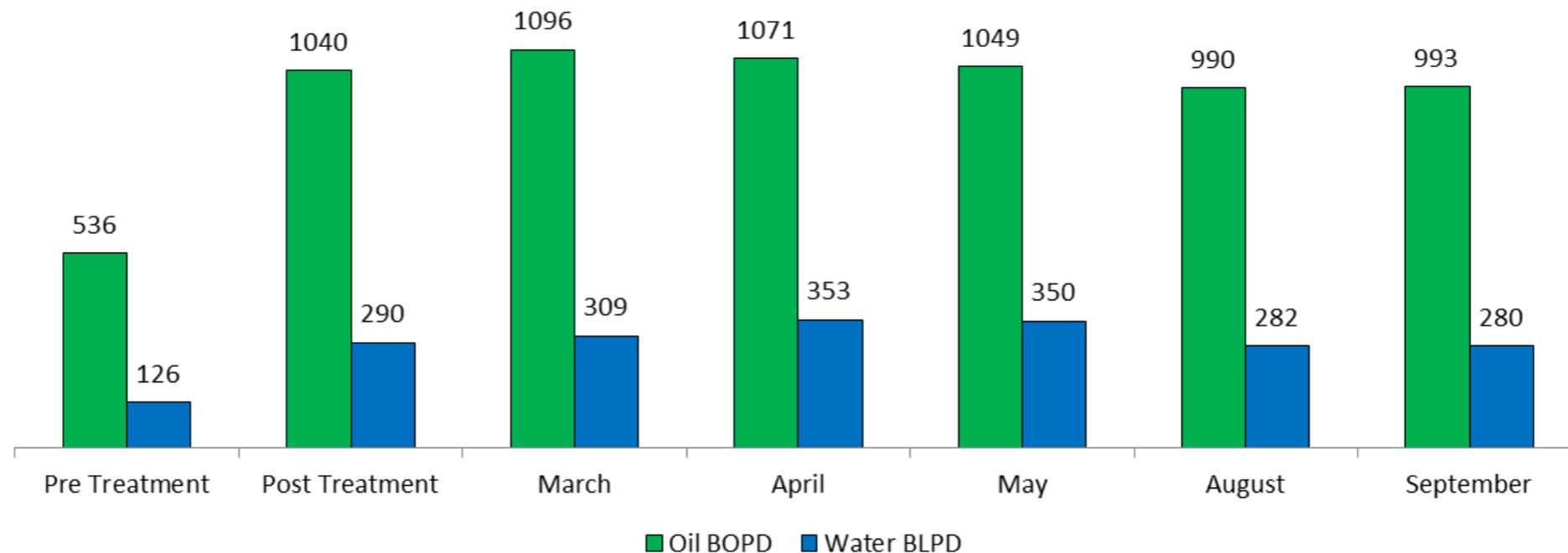


# Increase in the Well Production Rate

DFL before treatment – 2245  
 DFL after treatment – 1373  
 Formation – D3fm  
 Operating capacity – 16,2 m  
 PI before treatment – 0,55  
 PI after treatment – 1,84

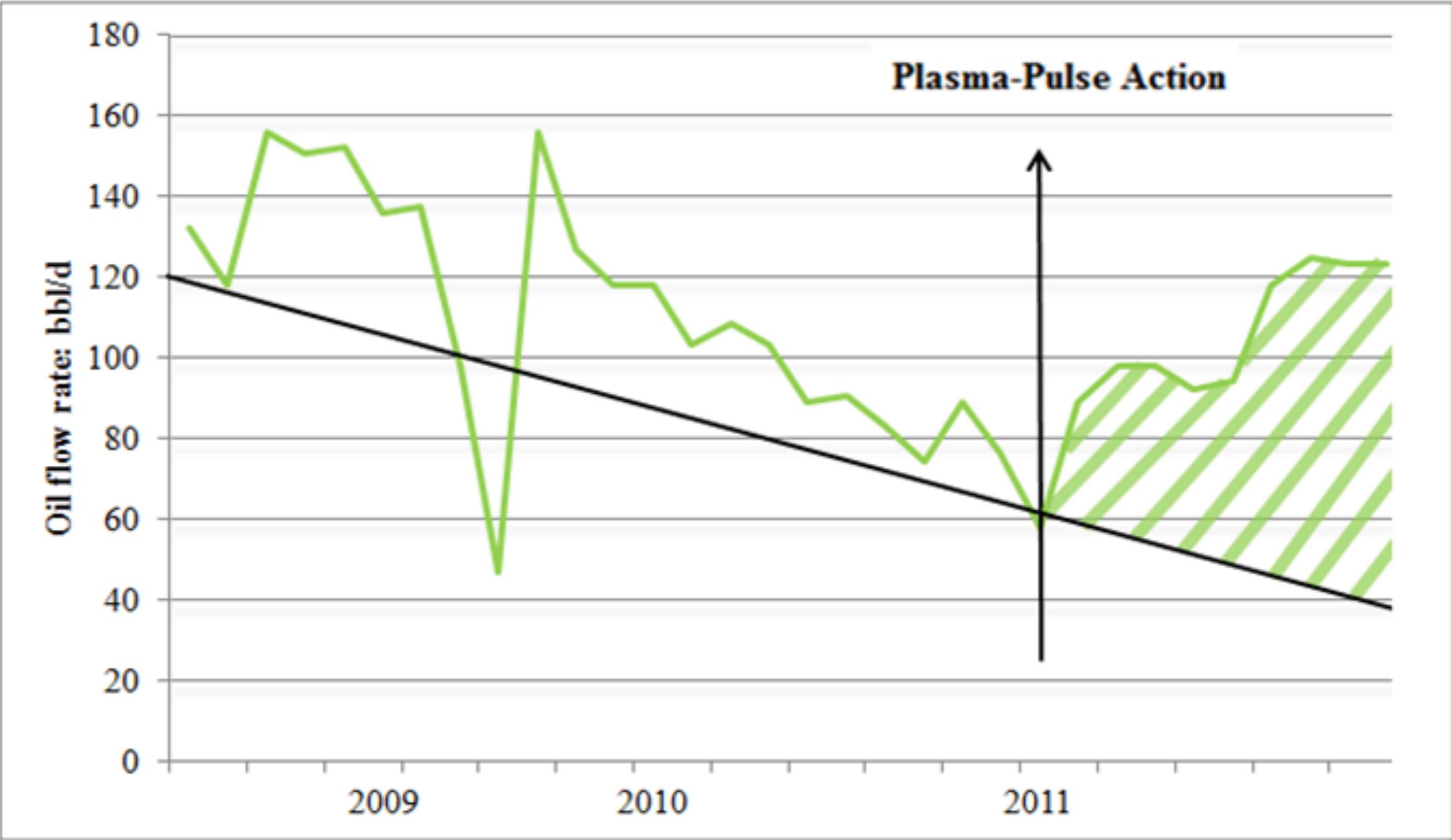
**Well #:** 70  
**Oil field:** Russia, Zapadno-Sikhoreyskoe  
 LLC Polar Lights Company  
**Reservoir:** Carbonate  
**Well Type:** Production Well

DFL = Dynamic Fluid Level, PI = Productivity Index



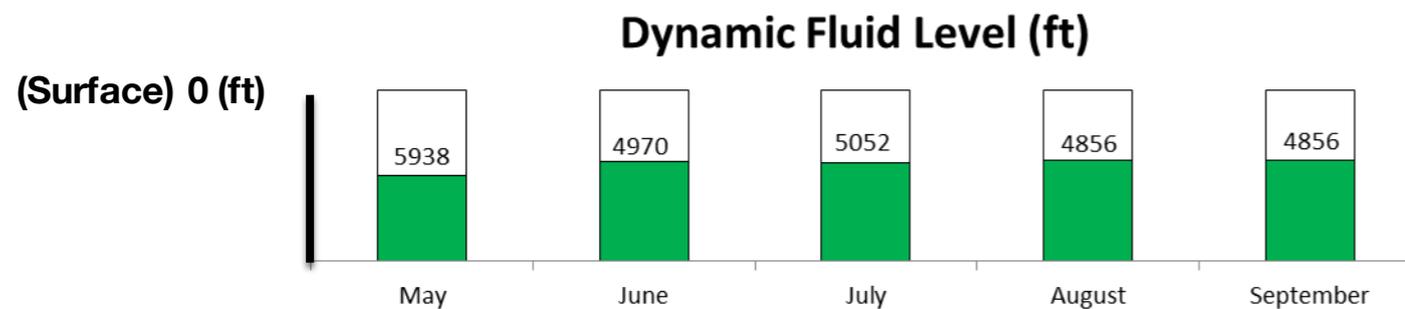
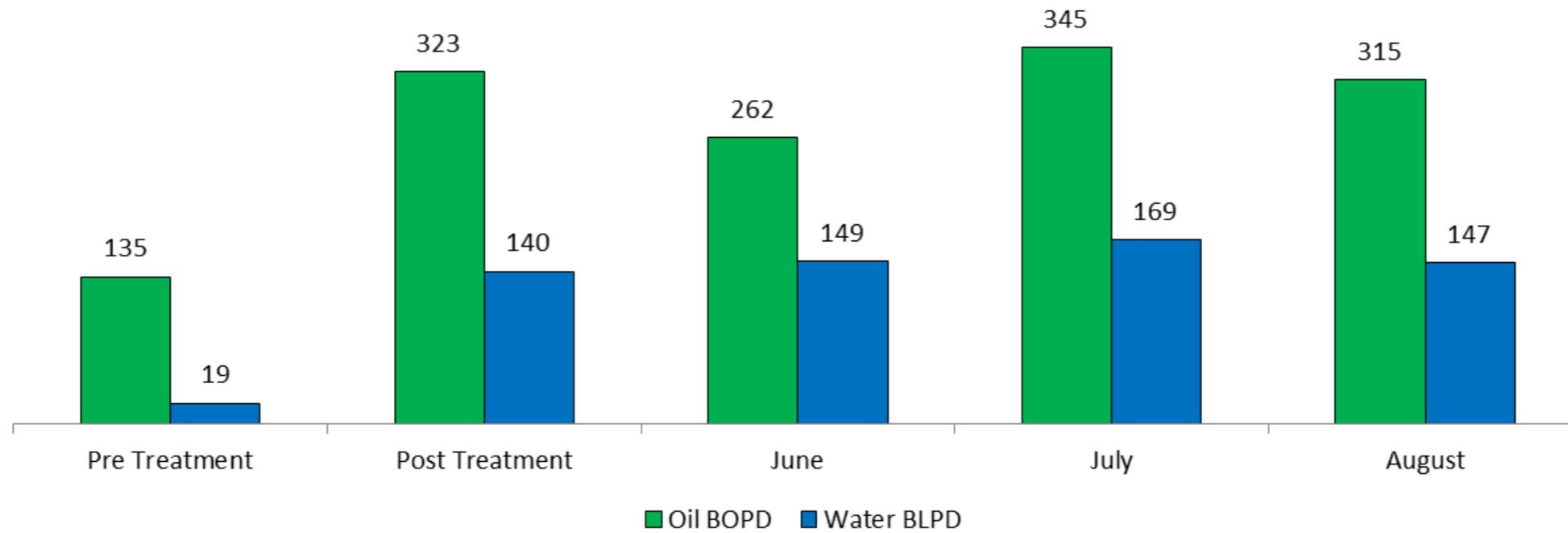
# Increase in the Well Production Rate

Well № XXX8 Vatyaganskoe Field



# Increased Productivity After Plasma Pulse Treatment

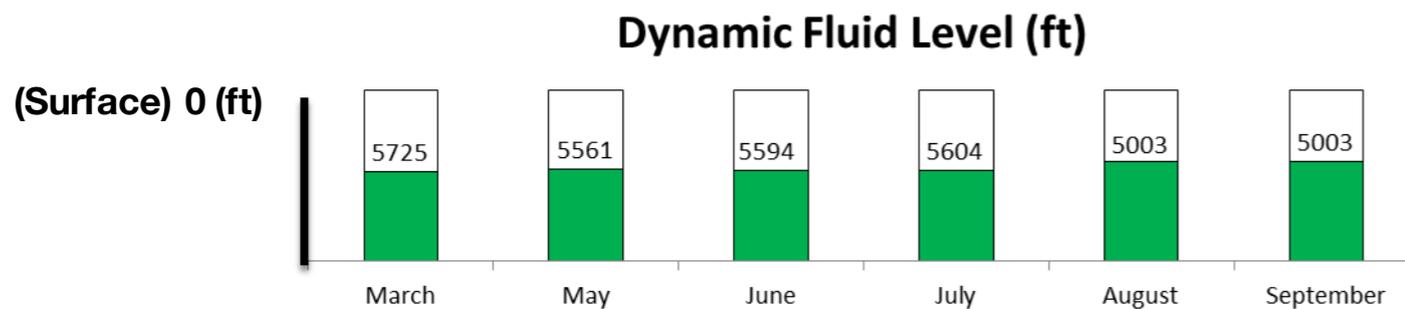
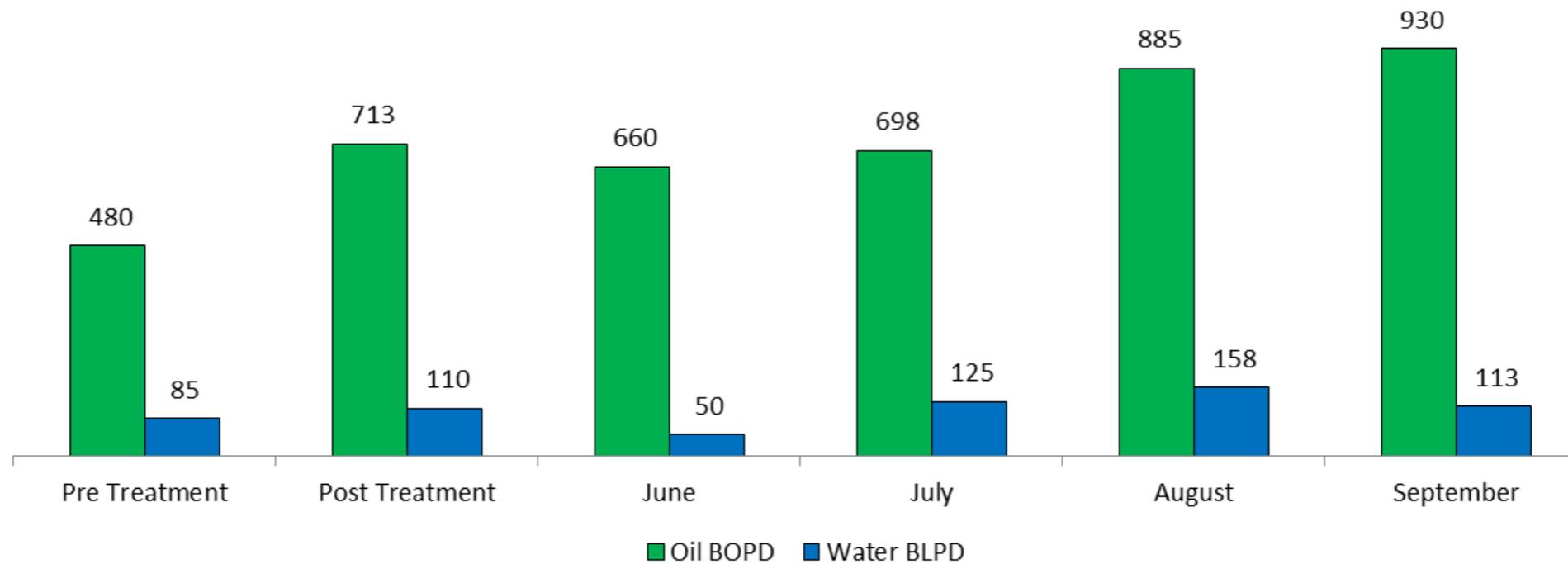
## (IN HYDRO-FRACKED FORMATION)



**Well #: 753**  
**Oil field: Vatyoganskoye**  
**Reservoir: Tight Sand**  
**Object: Enhance Oil Recovery**  
**Permeability: 3 mD**

# Increased Productivity After Plasma Pulse Treatment

## (IN HYDRO-FRACKED FORMATION)



**Well #:** 9138  
**Oil field:** Vatyoganskoye  
**Reservoir:** Tight Sand  
**Object:** Enhance Oil Recovery  
**Permeability:** 10 mD

# Decline Curve Before and After PPT

