

**Clean Water. No Waste.®**

**5X faster cleanup**

**In-situ Remediation**

**IWR PulseOx®-IWR** (In-Well Reactor) is a recirculatory in-situ chemical oxidation (ISCO) technology for the remediation of contaminated soil and groundwater. Each PulseOx-IWR is placed directly in a well or an existing monitor well, reducing installation costs by as much as 20-50%. Once installed the IWR process continuously injects and circulates ozone, hydrogen peroxide, oxygen and air into the groundwater. Soil and groundwater contaminants are effectively destroyed via powerful hydroxyl-radical based chemical oxidation which is up to 1-billion times faster than conventional ozone treatment. Importantly, hydroxyl radical treatment completely destroys organic contaminants to dissolved CO<sub>2</sub> and H<sub>2</sub>O, does not leave harmful residuals, alter groundwater pH, or produce reductive or corrosive conditions. Oxidant-rich groundwater conditions accelerate clean-up by promoting natural attenuation and healthy biological conditions across the site. PulseOx-IWR systems offer a safe, rapid, cost-effective, and environmentally sustainable option for soil and groundwater clean-up projects.

PulseOx-IWR systems offer a number of operating advantages as compared to other in-situ remediation technologies:

- Lower installation costs
- Minimal site disruption
- Effective for a wide range of contaminants
- No need for external treatment tanks
- Safe and environmentally friendly
- Rapid and efficient clean-up
- Promotes natural groundwater conditions
- Suitable for various site conditions

**System Features**

PulseOx-IWR systems offer a number of advantages for in-situ remediation.

- Effective for a wide range of contaminants
- Minimal site disruption
- No need for external treatment tanks
- Safe and environmentally friendly
- Rapid and efficient clean-up
- Promotes natural groundwater conditions
- Suitable for various site conditions

**Applications**

PulseOx IWR systems are suited to a range of in-situ remediation projects, including:

- Groundwater remediation
- Soil remediation
- Industrial site cleanup
- Leachate treatment
- Contaminated sediment remediation
- Air quality improvement

**Contaminants Treated**

PulseOx-IWR systems are effective for treating a wide range of contaminants, including:

- Volatile organic compounds (VOCs)
- Semi-volatile organic compounds (SVOCs)
- Petroleum hydrocarbons (PHCs)
- Chlorinated hydrocarbons (CHCs)
- Heavy metals
- Inorganic chemicals
- BTEX (Benzene, Toluene, Ethylbenzene, Xylenes)
- PCE (Perchloroethylene)
- TCE (Trichloroethylene)
- DCE (Dichloroethylene)
- DCM (Dichloromethane)
- Hexachlorocyclopentadiene (HCCP)
- Hexachlorobenzene (HCB)
- Polychlorinated biphenyls (PCBs)
- Polynuclear aromatic hydrocarbons (PAHs)
- Dieldrin
- Aldrin
- DDT
- Heptachlor epoxide
- Heptachlor
- Endrin
- Heptachlor hydride
- Heptachlor hydrolysis product
- Heptachlor lactone
- Heptachlor methyl
- Heptachlor methyl lactone
- Heptachlor methyl methyl ether
- Heptachlor methyl methyl ether hydrolysis product
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**How It Works**

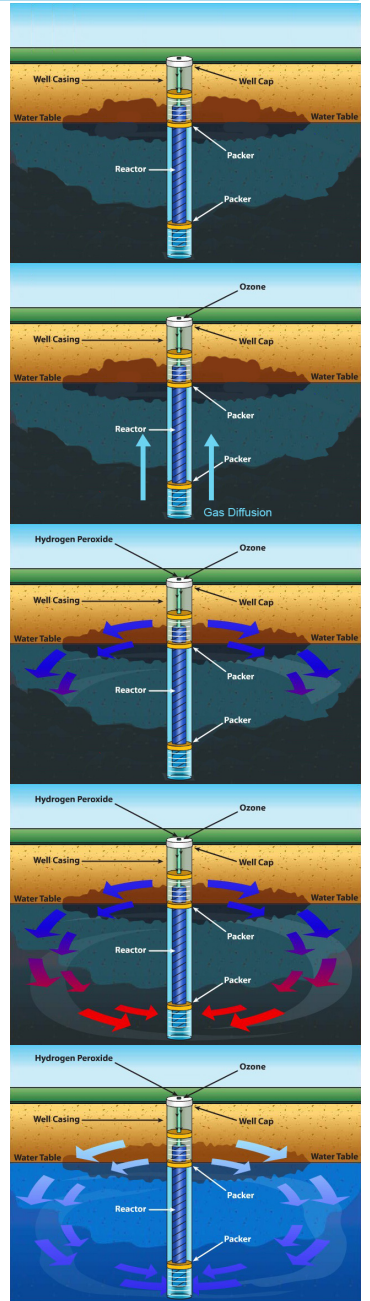
**Step 1**  
The IWR system is installed in an existing or new well. Chemical injection points are installed near the bottom and top of the well. Packers are installed to isolate the upper and lower injection points to setup the vertical circulation pattern.

**Step 2**  
Ozone gas (O<sub>3</sub>) is injected into the bottom of the IWR. The gas promotes upwelling of groundwater. As the groundwater rises, the ozone gas rapidly dissolves into the groundwater.

**Step 3**  
Hydrogen Peroxide (H<sub>2</sub>O<sub>2</sub>) is injected into the groundwater at a variety of locations of the IWR and forms hydroxyl radicals. The continuous circulation pattern pushes oxidant out into the formation.

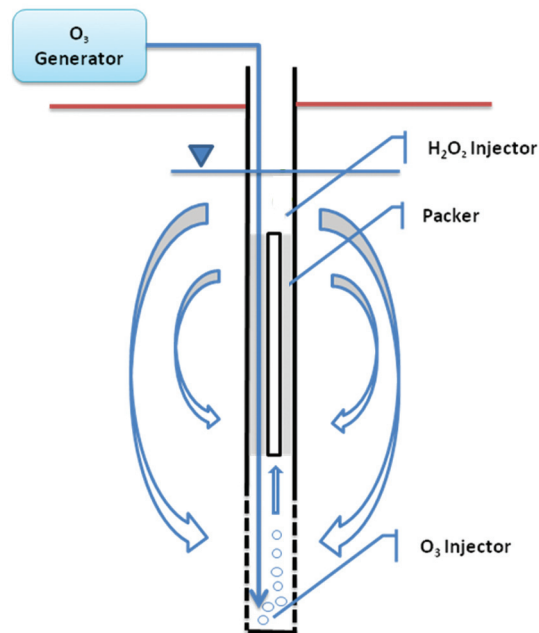
**Step 4**  
Oxidant rich (O<sub>3</sub>, O<sub>2</sub>, H<sub>2</sub>O<sub>2</sub>) groundwater is continuously circulated throughout the soils and groundwater surrounding the well to oxidize dissolved contaminants. Adsorbed, soil bound, or free-phase (LNAPL or DNAPL) contaminants are rapidly oxidized to carboxylic acid intermediaries or completely to dissolved CO<sub>2</sub> and H<sub>2</sub>O.

**Step 5**  
Oxidant rich groundwater promotes healthy groundwater conditions across the site to promote healthy natural aerobic biodegradation and natural attenuation.



PulseOx(R) - IWR Schematic

	IWR2	IWR4
Well Diameter	2"	4"
Min GW Depth	3ft	
Min Saturated Thickness	5'	
Max Radius of Influence	5'-200'	
Ozone Flow	0-5 #/day	
H <sub>2</sub> O <sub>2</sub> Flow	0-14 gal/day	
Oxygen Flow	0-25 scfh	0-45 scfh
Air Flow	0-5 scfm (varies based on site conditions)	



Process Advantages & Benefits	PulseOx <sup>®</sup>	IWR	Pump & Treat	Air Sparge	Hi-Press Air Inj.	Ozone Only	Peroxide Only Injec.	Conven. Peroxone	Fenton's Reagent	Potass. Perman.	Calcium Perman.
Most Aggressive Hydroxyl Chemistry	✓	✓	✓				✓	✓	✓		
Continuous Oxidant Recirculation		✓									
Delivers Most Hydroxyls to Contaminants	✓	✓	✓								
Up to 1,000,000x faster reaction Kinetics	✓	✓	✓					✓	✓		
More Complete Chemical Oxidation	✓	✓	✓			✓			✓	✓	✓
No Reaction Byproducts & Intermediaries	✓	✓	✓								
Promotes NAPL Destruction	✓	✓	✓	✓		✓					
Prevents Formation of Vinyl Chloride	✓	✓	✓			✓					
Effic. Destroys 1,4-dioxane, MTBE, DCA	✓	✓	✓								
Enhanced Aerobic Biodegradation	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Accelerated Cleanup Times	✓	✓			✓	✓	✓	✓	✓	✓	✓
Low Chemical Cost	✓	✓	✓	✓	✓	✓	✓	✓			
Low Power Cost	✓	✓	✓	✓	✓				✓	✓	✓
Provides More Stable pH Conditions	✓	✓	✓	✓	✓	✓	✓	✓			
Enhanced Process Control & Automation	✓	✓	✓	✓	✓	✓	✓	✓			
Improved Process Safety	✓	✓	✓	✓	✓						
Reduced Maintenance	✓	✓	✓								

✓ = Standard Feature/Benefit

PulseOx<sup>®</sup> is a registered trademark of APTwater, Inc.