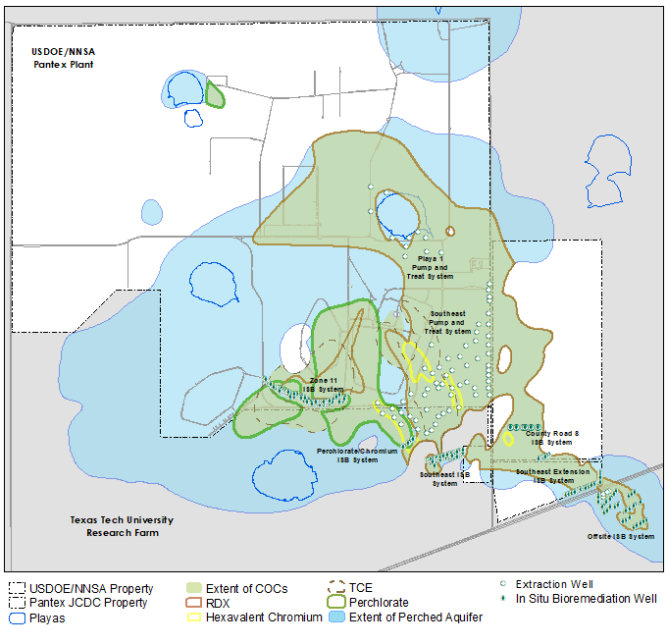
PANTEX ENVIRONMENTAL RESTORATION

In Situ Groundwater Bioremediation Systems

The Pantex Groundwater Resource Conservation and Recovery Act Facility Investigation Report identified impacts to perched groundwater that require corrective action. The Pantex Site Wide Human Health Risk Assessment found that perched groundwater underneath the Pantex Plant contains high explosives and other constituents that could migrate over time to the Ogallala Aquifer, the main drinking water source for the area. A Record of Decision (ROD) was issued in 2008 with concurrence of the Environmental Protection Agency (EPA) and Texas Commission on Environmental Quality (TCEQ) to address cleanup of the legacy contamination at the Pantex Plant. The Selected Remedy for perched groundwater is a combination of extraction and treatment in areas with greater than 15 feet of saturation and *in situ* bioremediation (ISB) treatment in the thinner areas. Pantex currently operates five ISB systems to cleanup groundwater plumes, with two more planned for operation at a later date.

The area of primary concern for in situ treatment is in the area southeast of the main Plant on Texas Tech University property. The fine-grained zone prevents vertical migration in most areas, but becomes thinner and more permeable in the southeast, so migration to the Ogallala Aquifer is more of a risk there. The area to the southeast also has thin saturation so pump and treat technology is not a viable option in that area. An area further southeast was noted after the first Five-Year Review as not being under control of the pump and treat system, so the high explosive plume was continuing to migrate offsite to the southeast. Another area identified for cleanup is located south of Zone 11 on Pantex property, which presents a concern for migration offsite to the Texas Tech University property. High explosives are the main contaminants treated by the ISB systems at Pantex, but chlorinated solvents, perchlorate, and hexavalent chromium are also remediated by this technology.

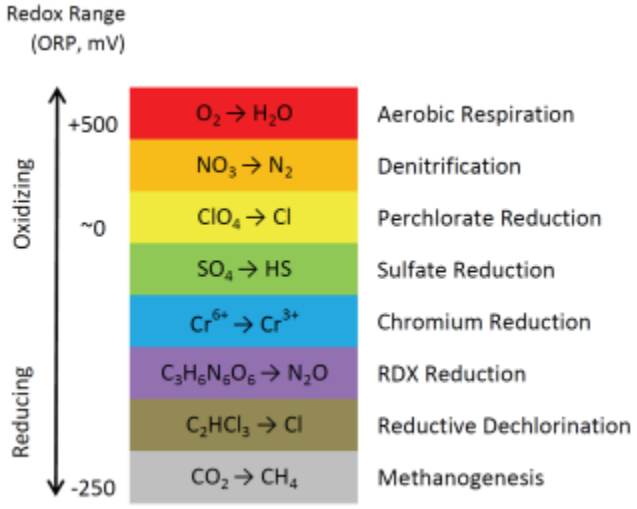


Plume Boundary and Groundwater Remedies, 2024

In 2024, five operating ISB systems consisted of 230 active ISB injection wells, 44 ISB extraction wells (named REC wells in figures), 21 treatment zone monitoring (TZM) wells, and 18 *in situ* performance-monitoring (ISPM) wells. The Southeast ISB was installed in the southeast area of the plume on Texas Tech property where the fine-grained zone is more permeable. The Southeast ISB Extension was installed at the southeast property boundary east of FM 2373 to prevent further offsite movement of the perched groundwater plumes. The Offsite ISB has been installed in stages to cleanup plumes that have moved offsite. The Zone 11 ISB was installed to intercept multiple contaminants moving towards Texas Tech University property to the south.

Pantex drilled wells for two new ISB Systems in 2024, the Perchlorate/Chromium (PCR) ISB and the County Road 8 (CR8) ISB. The PCR ISB was fully injected in 2024, however the CR8 ISB is awaiting installation of infrastructure and is planned for injection in 2026.

The objective of the ISB systems is to establish an anaerobic biodegradation treatment zone capable of reducing contaminants to levels that are safe for residential use. This is accomplished by injecting the necessary amendments or nutrients into the treatment zone wells to stimulate resident bacteria. As the naturally occurring bacteria feed and multiply, oxygen is removed from the injected area and deep reducing conditions are established for treatment of the contaminants. The ISB must establish reducing conditions to treat perchlorate, chromium VI, high explosives, and achieve reductive dechlorination of solvents like TCE. The figure below shows the conditions required to breakdown various contaminants.



Pantex monitors the treatment zone to evaluate the health of the bacteria so injection frequencies and volume of food source can be adjusted. Downgradient wells are also monitored to evaluate the effectiveness of treatment. As long as optimal subsurface reducing conditions and a food source are available, a diverse bacterial community can be sustained which leads to in situ treatment of contaminants.

The Southeast ISB system was installed in 2007 on the Texas Tech University property as an early action. The injection wells were drilled in a line perpendicular to the hydraulic gradient so the water flowing through the treatment zone will be treated before reaching the area beneath Texas Tech property where the fine-grained zone layer becomes thinner and more permeable.

Amendment Tanks and Control Trailers at the ISBs

This system has been significantly impacted by the dewatering operations by the pump and treat systems; however, Pantex was able to inject this system in 2025. Pantex will continue to monitor to determine whether further injections are possible and necessary.

The Southeast ISB Extension was installed in 2017 after discovery of the high explosive plume expansion to an offsite property. The system was designed to prevent further movement of the groundwater plume offsite in areas that are not captured by the pump and treat system and water saturation is too thin to pump. Based on the rate of perched groundwater flow and estimated longevity of molasses, injections are necessary every 12 months.

The PCR ISB was drilled in 2024 between the Southeast ISB and Zone 11 ISB to treat perchlorate and Cr(VI) plumes as they move towards the southeast. The PCR ISB was injected for the first time in fall 2024 and again in 2025. This system will be injected every three years after this year's injection.

The Offsite ISB installation began in 2020 and is mostly complete with small additions still to be constructed. This system was designed to treat HE contaminants that

have moved offsite in thinner areas of perched saturation. This system was injected with molasses in the spring and fall of 2024 and is scheduled to be injected twice annually. This system uses water pumped out of the perched aquifer from REC wells before being reinjected with amendment into ISB wells, creating a circulation system that more efficiently distributes the amendment throughout the entire system. This allows for the entire offsite plume to be treated in a shorter timeframe, while other systems treat water as it moves through the system.

The Zone 11 ISB system was installed in 2009 as part of the original final remedy with multiple expansions occurring as the plumes have changed direction due to the removal of water by the pump and treat systems. The latest phase of installation occurred in 2021. The injection wells were installed so water flowing through this zone will be treated before it reaches the area to the south on Texas Tech property near Playa 4. Based on the rate of perched groundwater flow and longevity of molasses, injections are necessary every 12 months.

The Southeast ISB primarily treats the high explosive RDX and hexavalent chromium. This system has successfully treated high explosives and hexavalent chromium below safe levels at most downgradient wells. One downgradient well on the southwest end of the system demonstrates partial treatment. Pantex converted this well into an injection well in 2025 to target the persistent contamination at this location. This well was injected in 2025 and will be monitored as treatment establishes. Due to the decrease in water levels from the operation of the pump and treat system, this system is near the end of injections. An injection event was completed in 2025, and future injections will only be performed as indicated by monitoring data.

The Southeast ISB Extension primarily treats the high explosive RDX and 4-amino-2,6-dinitrotoluene (a breakdown product of the high explosive TNT). The system was injected once in 2024. Injections for the system are necessary every 12 months. Treatment effects are beginning to be observed in downgradient wells. Treatment effects inside the ISB have already been established.

The Zone 11 ISB primarily treats the organic solvent trichloroethene (TCE) and perchlorate. The full system was injected once in 2024. This system has successfully treated perchlorate to safe levels and TCE has been greatly reduced and is meeting safe levels through most of the ISB. Other areas are expected to meet safe levels in the near future. Breakdown products of TCE are also declining, with most wells meeting safe levels. The amendment strategy was changed in 2018 from emulsified soybean oil to a higher dosage of a more soluble carbon source (molasses) to provide better distribution of the amendment throughout the zone. It is expected that the change in amendment distribution will completely treat TCE and its breakdown products to safe drinking levels. Pantex added new wells in 2021 with closer spacing to allow for injection with emulsified vegetable oil, a longer lasting amendment. Those wells will only require reinjection every 3 to 5 years. Two additional injection wells were installed in 2024 to extend the treatment zone further northeast to control the movement of the TCE plume in that area.

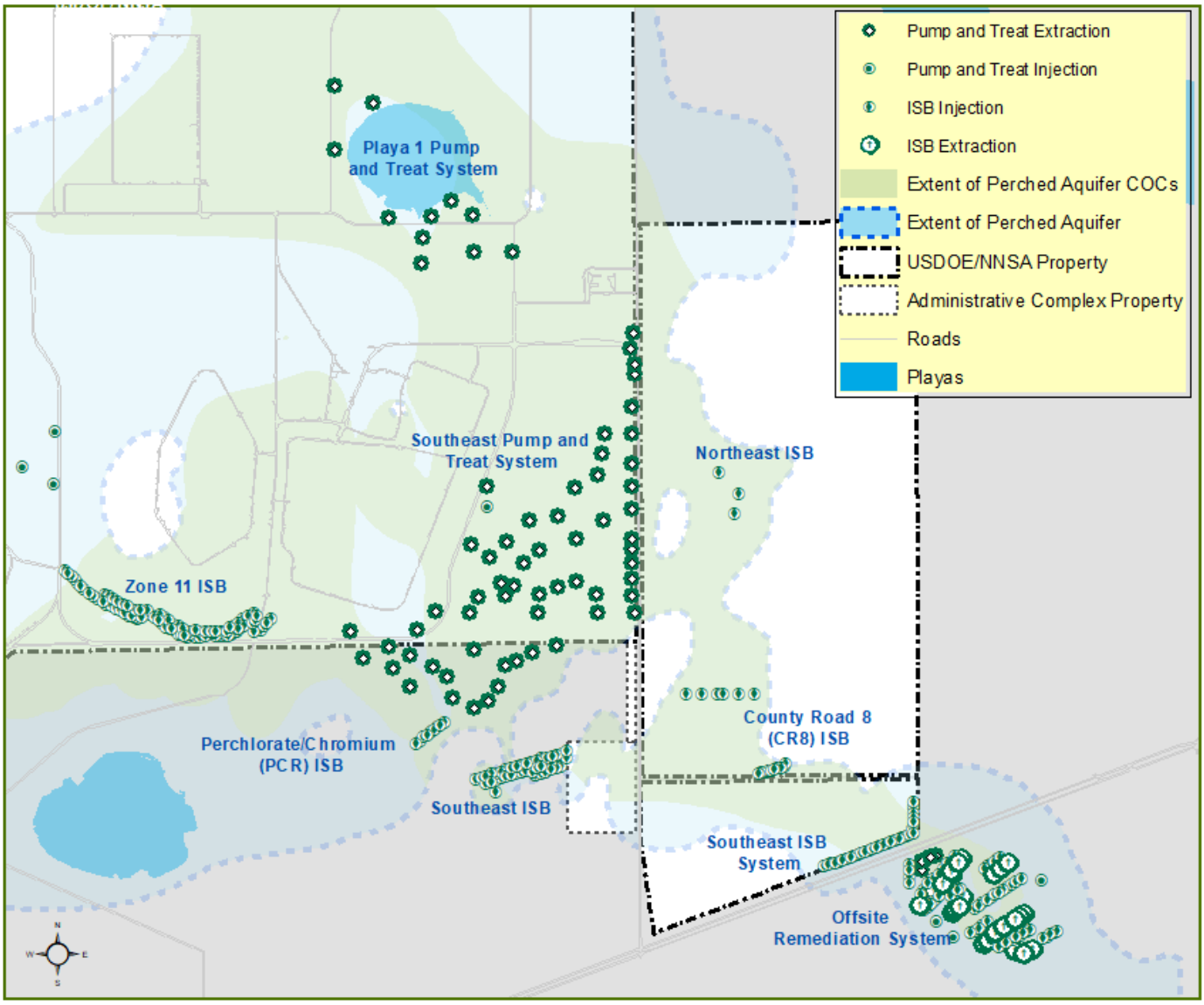
To address HE contamination that moved onto a neighboring property, Pantex began installing an Offsite ISB system in 2020. This ISB is located to the southeast of Pantex-owned property, south of Highway 60. The main installation phase of this system was completed in 2023 and two injection events occurred in 2024. Based on the use of molasses, injections are planned every six months at differing parts of the system. Injection plans will follow the schedule that was designed using fate and transport modeling and optimization modeling.

Injection Trailers at Zone 11 ISB

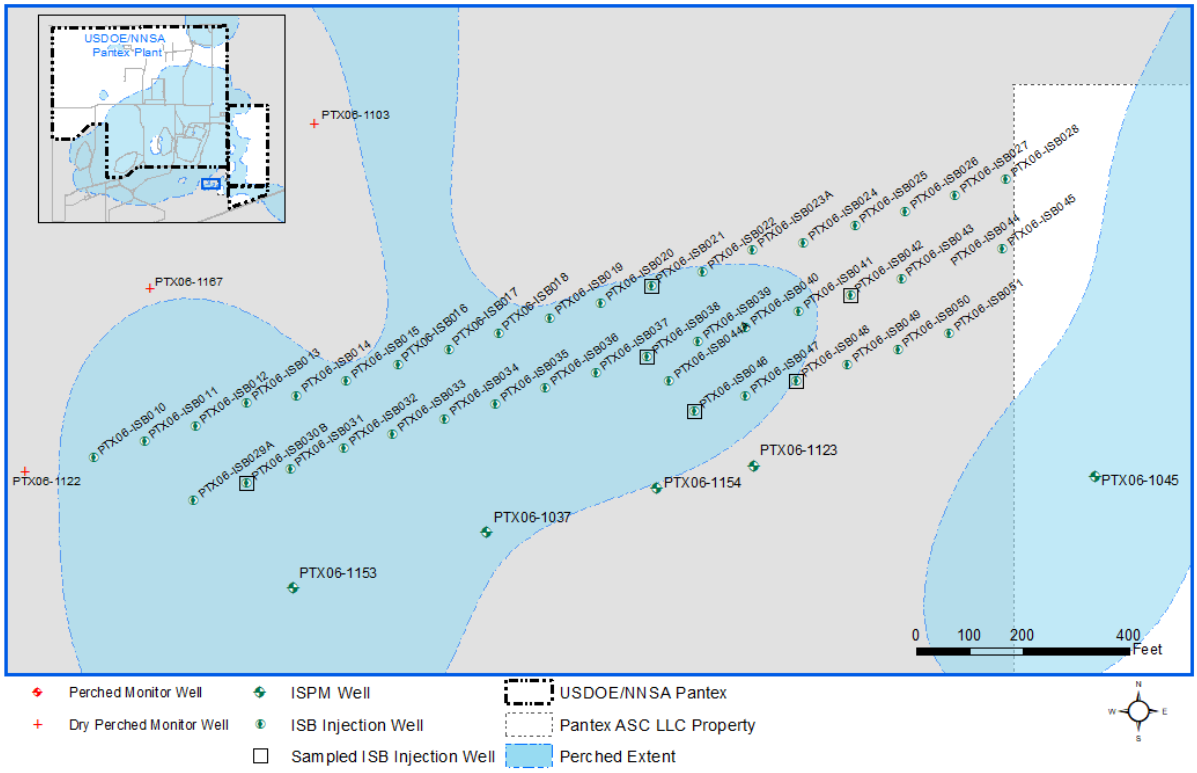
It is expected to take several years of treatment to allow the contaminant plumes to move through the

treatment zones. Pantex will continue to operate this action and provide results in progress reports that can be found at pantex.energy.gov. This action is one of several positive steps Pantex is taking to protect the public and Ogallala Aquifer. Pantex has been actively working on the installation of the CR8 ISB to address the heart of the high explosive plume that is moving offsite. Six extraction wells located east of FM 2373 are being converted to ISB injection wells and will be tied into the CR8 ISB. This system will not be injected until 2026.

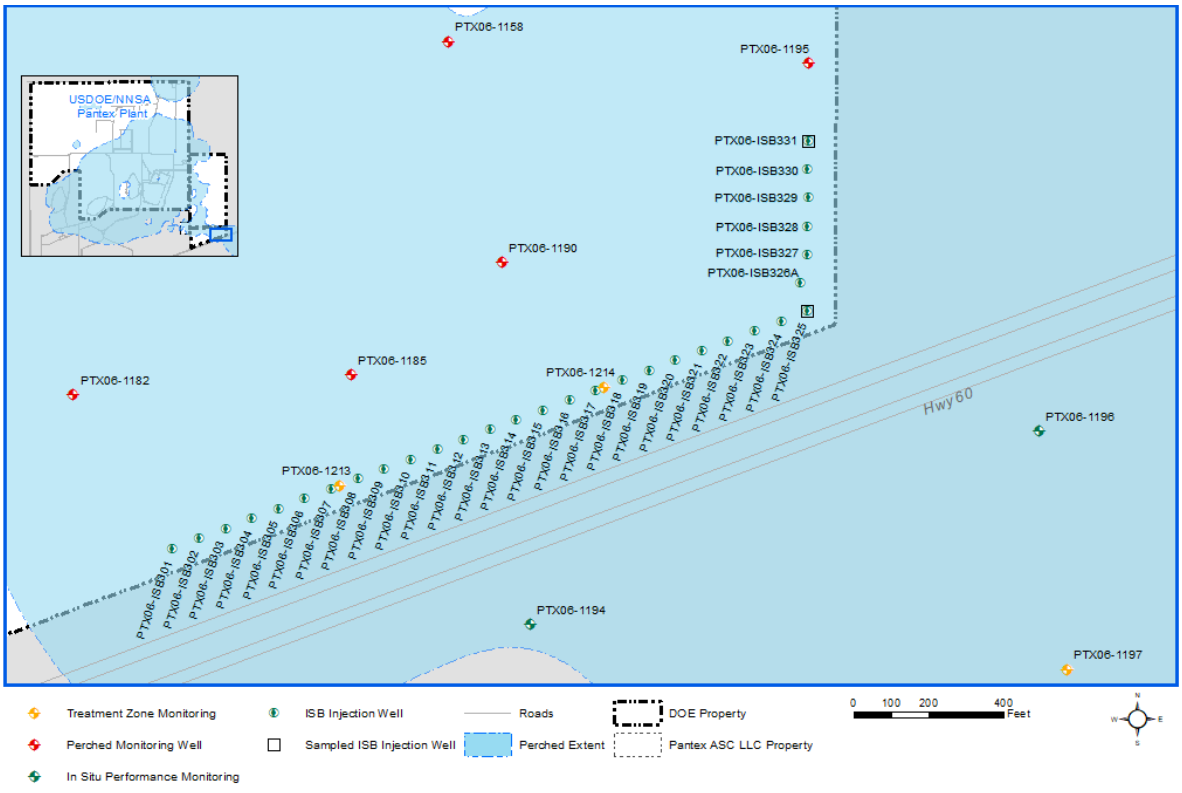
Additionally, three previously installed wells that were originally for use with a mobile pump and treat system have been converted and will now be used for injection. These wells will comprise the Northeast ISB. This system will target high concentrations of RDX that continue to move to the southeast and offsite. New infrastructure is required at the Northeast ISB, and Pantex plans to install this infostructure and begin injections at the Northeast ISB as funding becomes available.



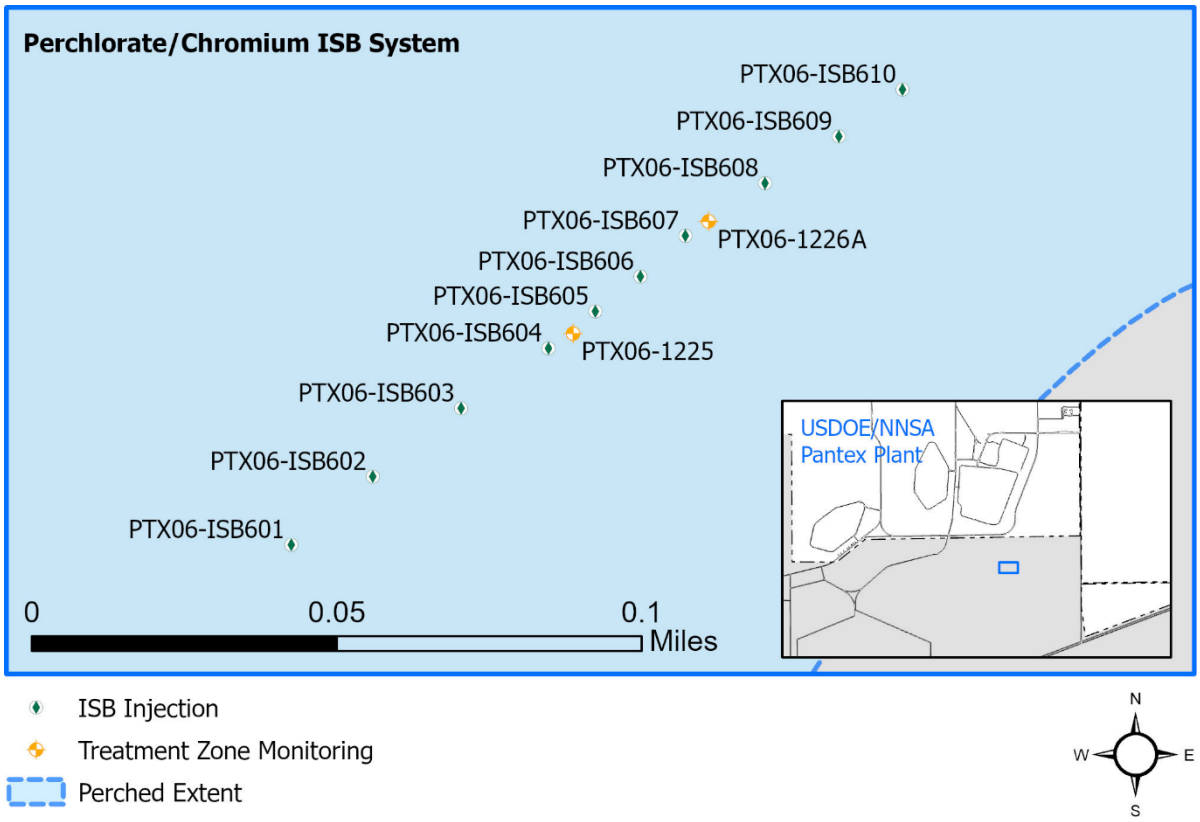
Pantex Remedial Action Systems with Planned Expansions



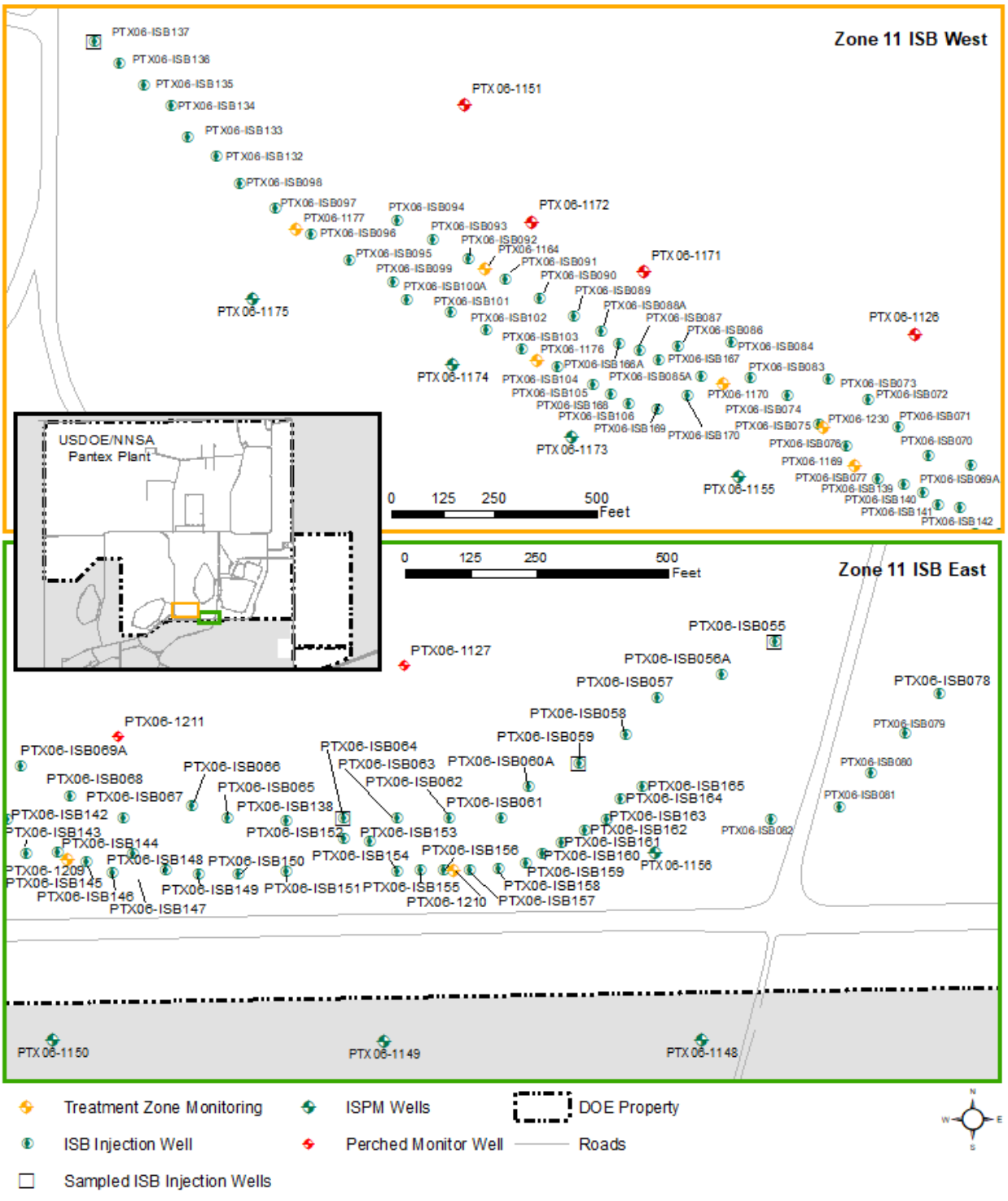
Southeast ISB System, 2024



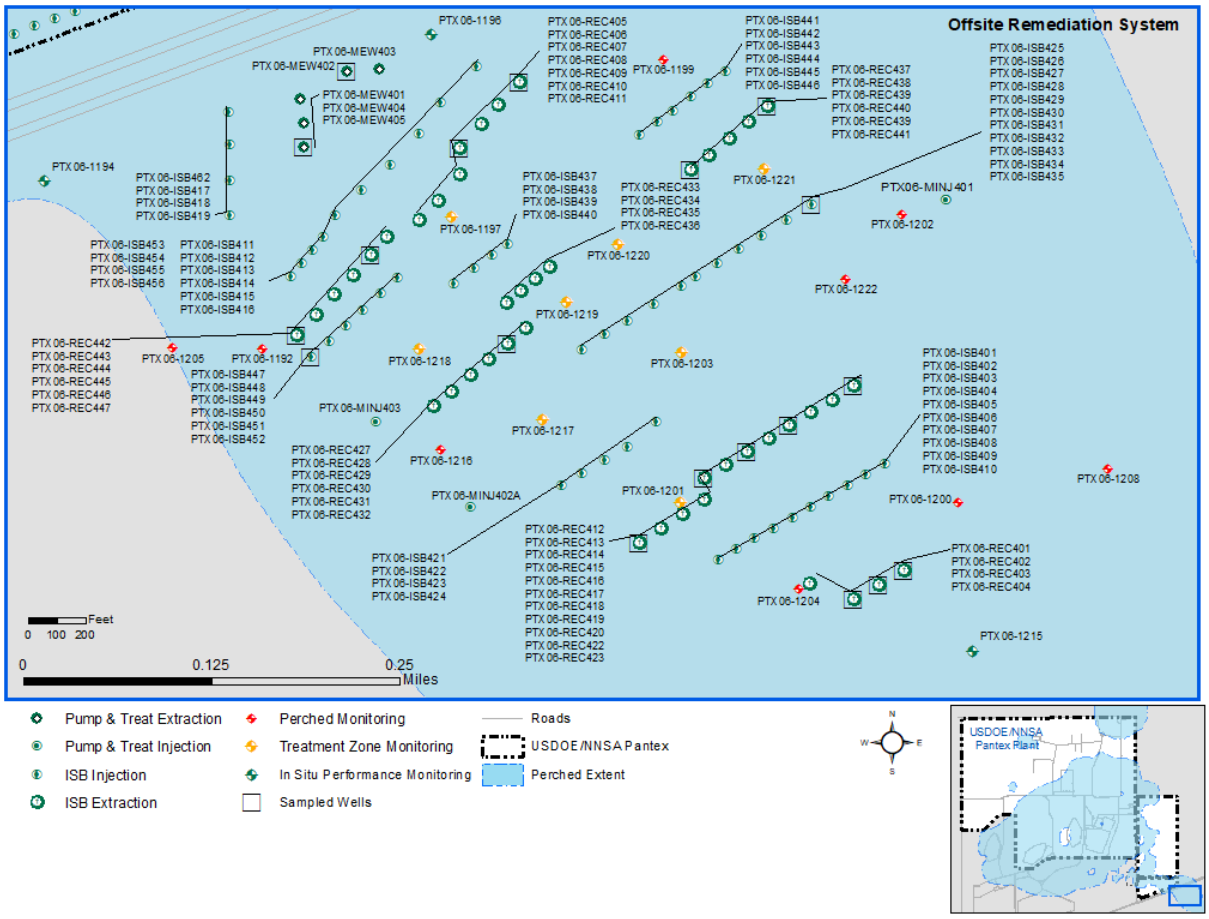
Southeast Extension ISB System, 2024



Perchlorate/Chromium ISB System, 2024



Zone 11 ISB System, 2024



Offsite ISB System, 2024