



City of Elk Grove
Dry Well Project
*Guidance and Lessons
Learned Document*

Guidance and Lesson Learned from the Elk Grove Dry Well Project

The Elk Grove Dry Well Project (project) was a four-year study to investigate the risk of groundwater contamination associated with the use of infiltrating stormwater through dry wells. The project involved a large field component that included the installation of two dry wells with pretreatment and a network of groundwater monitoring wells. The project has two study sites located in Elk Grove, California. The first site was the City of Elk Grove's Corporation Yard, a 0.6-acre parking facility that is a bus fleet servicing area and maintenance yard, and the second site was the Strawberry Detention Basin, a water quality basin that collects stormwater from a 168-acre residential neighborhood.

As part of the project study, stormwater and groundwater samples were collected for two years and analyzed for over 200 contaminants. Estimates of infiltration rates were also made. A companion modeling study of the fate and transport of contaminants through the vadose zone was performed. Scientific and government reports evaluating the risk to groundwater quality associated with dry well use were reviewed and compiled in a literature review (annotated bibliography). Lastly, information from other states with developed dry well programs, often known as underground injection control systems, was summarized in fact sheets with the goal of understanding the regulations, permitting, siting, and design guidelines used elsewhere.

This guidance document summarizes some of the key lessons learned from this work.

1. Siting

The siting of a dry well involves consideration of the land use and types of contaminants that are likely to be associated with any particular land use, the location of other public infrastructure, such as public supply wells, presence of any existing contaminants in the soils, and subsurface lithology. The following are key siting considerations:

- **Avoid sites where hazardous chemicals are used or handled.** It is wise to avoid installing dry wells where hazardous chemicals are used, even if control measures are in place. Stormwater runoff from the Corporation Yard contained very high levels of some metals as well as motor oil. In retrospect this is not surprising given the activities at the site. The washing of buses and their undercarriage, and servicing the vehicles, is likely the source of these contaminants. As a result of finding elevated levels of stormwater contaminants and the challenges of managing runoff at such a busy site, the City of Elk Grove decided to decommission this dry well at the completion of the project. Most other states with developed underground injection control programs, such as Washington and Oregon, do not allow dry wells to be located at vehicle servicing areas, gas stations, and other locations where hazardous chemicals could enter stormwater. They do permit dry wells, however, in the parking lots of such sites if there is no route for the hazardous chemicals to reach the dry well if a spill should occur.
- **Avoid sites where soils are contaminated.** Leaching of hazardous chemicals from soils and entrainment in stormwater runoff also poses a risk. Soils at contaminated sites

require containment and mitigation, making dry well use inappropriate. Although soils at the two project sites in Elk Grove did not contain contaminants, this prohibition is commonly enforced in other states where dry wells are used.

- **Avoid sensitive areas.** It is prudent to avoid placing dry wells near public supply wells, water lines, creeks, and other sensitive areas. In Washington, for example, a 500-foot setback from public supply wells and a 100 foot setback from a domestic well are required. By following these precautions, if contaminants get into a dry well, adjacent infrastructure or natural areas are unlikely to be adversely affected.
- **Land ownership matters.** It is simpler to place dry wells on public lands than on private lands. Oversight of construction, operation and maintenance, and monitoring of influent stormwater can be accomplished more easily if dry wells are sited on public lands such as within the public right of way, in parks, or other public holdings. City or county maintenance staff can oversee dry well maintenance when the dry wells are easily accessible. The long-term concern is proper maintenance and cleaning to prevent clogging with sediment and debris. For example, in Portland, about half of their 20,000 dry wells are located within the public right of way, collecting runoff from sidewalks and streets. However, dry wells have been successfully located on private lands as well. Usually a covenant agreement is required when the development is first constructed that spells out the terms of maintenance and monitoring for these privately owned dry wells. In Oregon and Washington for example, dry wells that only receive roof runoff, from a private home or business, typically containing few or no contaminants, do not require such agreements. For the Elk Grove project, both study sites were located on public lands which facilitated construction oversight, maintenance, and monitoring at odd hours.
- **Use of dry wells in detention basins should be assessed on a case-by-case basis.** Detention basins are not necessarily the ideal location for dry wells. At the Strawberry Detention Basin (water quality basin), the rate of stormwater infiltration through the dry well decreased over the course of the winter, from 46 to 21 gallons per minute. An important factor linked to this decline was saturation of the vadose zone. The rate at which runoff moved through the dry well decreased as the rainy season progress, the water table rose, and presumably the degree of saturation in the vadose zone increased, although this was never directly measured. In contrast, there was not a declining rate of infiltration at the Corporation Yard site, an expansive paved area where the only path for stormwater to enter the subsurface was the single project dry well. However, if a greater amount of sand and gravel, material that can infiltrate large volumes of water, had characterized the lithology at Strawberry Detention Basin, the behavior of the dry well might have been quite different. The subsurface conditions at any prospective dry wells location, including detention basins, is the key factor in assessing if the site is likely to support reliable rates of infiltration throughout the rainy season.
- **Treat clay soils as an asset.** Clay soils are usually viewed as a problem when it comes to infiltrating stormwater. When clay is near the land surface, it acts as a barrier to

infiltration, and is the reason dry wells are needed to obtain meaningful infiltration rates. However, in the vadose zone, clay units serve a valuable function by retarding the movement of contaminants. For the Elk Grove project both dry wells were completed above a clay unit, forcing runoff to leave the dry well through boreholes in the sides and releasing the water above the clay layer. Compared to sand or silt, clay has a very large surface areas (10 m²/g) and adsorptive capacity. Thus, clay can play a role in attenuating the movement of pollutants, decreasing the risk of groundwater quality degradation. In the state of Washington, this factor is considered when determining required pretreatment. The amount of clay in the vadose zone and the concentration of stormwater pollutants are used to determine the type of pretreatment required for new dry wells.

2. Design and Construction

The design of the dry well system has a major influence on its functionality, especially its ability to capture pollutants and prevent them from entering the subsurface. Pretreatment features, both structural and vegetated, are important design factors. Similarly, in the actual construction of dry wells, it is important to ensure that the plans are implemented as designed and unanticipated issues are properly addressed. This is especially important because dry wells are a relatively new technology in California and many construction contractors do not have significant dry well experience. The following are important design and construction considerations:

- **Pretreatment of stormwater is essential.** Pretreatment can occur in the form of vegetated swales, bioretention cells, or a water quality basin. Structural pretreatment usually refers to a sedimentation well or manhole; usually a deep concrete vault designed to capture sediment. Experiences performing this study as well as information from elsewhere suggests that pretreatment is essential to protect groundwater.
 - **Vegetated Pretreatment.** Pretreatment for the Elk Grove project consisted of a deep grassy swale at one site and an existing water quality basin at the other site. Both were effective at removing sediment, measured as total suspended solids, from stormwater; approximately 50% removal efficiency was measured for the water quality basin and 65% for the grassy swale at the Corporation Yard. Given that up to 70% of metals and organics in stormwater are found adsorbed to sediment, preventing sediment from entering the dry well not only prevents clogging, but also reduces the pollutant load. Vegetated pretreatment might be especially important to sequester (via foliar absorption) some of the water soluble pesticides such as the neonicotinoid pesticides. This is an area that requires additional research.
 - **Structural Pretreatment.** Sedimentation wells/manholes are the main form of structural pretreatment. The sedimentation well design for the Elk Grove project did not function as planned due to design flaws. The 1 – 2 feet of depth beneath the pipe connecting the sedimentation well to the dry well was insufficient to permit sediment to settle. In Portland, their sedimentation manholes are typically 3 feet wide and 10

feet deep. Torrent Resources, who manufactures and installs dry wells in the western United States, designs their sedimentation wells about 15 feet deep. Unfortunately, when the design of the sedimentation well was developed at the beginning of the project, the team lacked this information. Torrent Resources¹ has estimated that their system, composed of two sedimentation wells, with the dry well housed within the second, removes about 90% of particulates. Given the Elk Grove team's experience with vegetated pretreatment, which removed about 55-60% of suspended sediment, a rough estimate was made that a properly design sedimentation well could remove an additional 30% of suspended sediments. Structural pretreatment is the primary means of removing sediment and associated pollutants in major cities such as Phoenix, Arizona and Portland, Oregon. Monitoring in Portland, in particular, has shown that their sedimentation manholes remove the large majority of metals and organic contaminants, such as polycyclic aromatic hydrocarbons, from stormwater runoff.

- **A minimum vertical separation from the water table should be maintained.** Other states often use a 10-foot vertical separation distance between the bottom of the dry well and the seasonal high water table as a benchmark. In some cases, the distances are as small as 5 feet or less. The depth of the water table is an important factor to consider in siting and constructing a dry well to permit a minimum amount of pollutant attenuation. In some circumstances, the water table might be so high that dry wells might not be useful. In other cases, the depth of the dry well might need to be reduced to account for shallower depths of the water table.
- **Dry well construction requires careful management.** The use of highly-engineered dry wells is relatively new in California and as such, there is not an abundance of experienced consultants and construction contractors. Some experienced design/build firms do exist. However, should a local construction contractor be selected to perform the installation of dry well system, careful oversight of the project is essential to avoid future problems. Problems were experienced with dry well construction in the Elk Grove project that required removing 5 feet of sand from the dry well and replacing it with the correct ratio of sand to gravel as indicated in the design plans. The contractor did not follow the design details, which lead to stormwater flows and infiltration being impeded. More careful oversight could have avoided this problem.
- **Dry wells should be constructed with a shut off valve.** The dry wells used in the project were designed with a shut off valve that was placed in the pipe connecting the sedimentation well and the dry well that could stop flow into the dry well in an emergency. This valve could be used if a chemical spill occurred, if a large amount of debris generated from a large storm might clog the well, or other unexpected circumstance developed. In the Elk Grove project, the shut off valve was used a few times when large amounts of debris were entrained in stormwater runoff. If dry wells were constructed in the public right of way, and should an accident occur, emergency

¹ References to Torrent Resources do not constitute an endorsement of their products or services.

responder would be able to prevent chemicals from entering the system by closing the valve.

3. Monitoring

- **Stormwater entering the dry well should be monitored.** The only way to know if contaminants are entering the dry well at a level that may pose a risk to groundwater quality is to test the stormwater entering the well. In the Elk Grove project, monitoring was performed at the first flush of the rainy season, and multiple times during the water year. Over 200 contaminants were evaluated in the classes of volatile and semi-volatile organics, herbicides, pyrethroid pesticides, metals, and general mineral and physical parameters. In Oregon, sites that are considered 'low-risk', newly installed wells are monitored twice a year for the first two years, then yearly thereafter. In Portland, however, where the city owns 9000 dry wells, wells at 15 fixed sites and 15 rotating sites are monitored six times per year for a set of priority pollutants. If the concentration exceeds their criteria value, usually the Maximum Contaminant Levels (MCL), a series of control steps are taken that include reducing or eliminating the source of the contaminant, adding additional pretreatment, or in the worst cases, decommissioning the dry well. Based on the experience gained from this project, the contaminants that appeared to warrant regular monitoring would include metals, a small list of semi-volatile organics, pyrethroid pesticides, and total suspended solids. In addition, pesticides which are increasing in use, especially those that are more water soluble than pyrethroids, should be included, specifically imidacloprid and fipronil.
- **Groundwater quality should primarily be evaluated with appropriate vadose zone modeling.** Extensive groundwater monitoring was performed as part of the Elk Grove project. Most of the well samples showed no evidence of contaminants, except for arsenic and chromium, which are naturally occurring. Vadose zone modeling that was also performed helped to explain the reason for the lack of detections. Most pollutants would not reach the water table at detectable levels for many years, decades, or, in some cases, centuries. Exceptions to this general rule were water soluble pesticides such as imidacloprid. Given these facts, and the expense of performing groundwater monitoring, regular groundwater monitoring from a network of wells does not appear to be a useful investment. Instead, limited groundwater monitoring, using a small number of strategically placed wells, could serve as a safeguard. As required in Oregon, vadose zone modeling can serve as useful alternative that can provide valuable information on the fate and transport of contaminants that might have entered the dry well. One dimensional vadose zone modeling can be performed with either a spreadsheet or the open source software Hydrus. University of California at Davis hydrologists is preparing guidance on the methods for performing this analysis.

4. Regulatory Issues

- **Dry well permitting and use varies widely in California.** Significant effort was invested in obtaining permits to install the two dry wells used in this project. The construction of the

dry wells had to be modified to meet certain requirements applied to water wells. This experience reflects on the broader issue of the different regulatory environments in California. In Southern California, over 10,000 dry wells have been installed. Permitting is handled at the local level, where specific conditions of construction and management are agreed upon with the contractor. In contrast, in Northern California, relatively few dry wells have been constructed. The regulatory climate is much more cautious than in the Los Angeles/San Diego area, likely due to the differences in the water resources. In the Sacramento region, the County permits dry wells as water wells, following the guidelines of Department of Water Resources (DWR) Bulletin 74-81 and 74-90. This bulletin identifies stormwater as a waste product and dry wells as one type of well to which water well standards apply. While permitting in Northern California serves as a barrier to using dry well technology, in Southern California, the interpretation of DWR's bulletins does not hinder permitting and construction. Requirements for construction and maintenance are applied in a piecemeal fashion in California. The need for state oversight of a dry well program to establish consistent standards for construction, siting, design, and maintenance is clear.

Conclusions

The Elk Grove dry well project team learned valuable lessons about dry well siting, design, construction, overcoming permitting challenges, and the value of stormwater and groundwater monitoring and modeling that have been summarized above. Additionally, the practices followed in neighboring states, all of which have had wide-reaching underground injection control programs in existence for over a decade, have been reviewed. The conclusions drawn from the Elk Grove project are consistent with many of the practices in other states: that is, dry wells can be safely used to manage urban runoff and recharge the aquifer when appropriate safeguards are in place through siting, design and maintenance.