3.10 HYDROLOGY AND WATER QUALITY

This section describes the existing hydrology and water quality conditions for the LRDP area and analyzes the potential for the 2021 LRDP to affect water quality, including resulting in substantial siltation or erosion, cause flooding due to the alteration of drainage patterns, or to deplete groundwater supplies or interfere with groundwater recharge.

Public comments were received in response to the NOP (See Appendix B) related to hydrology and water quality identified concerns regarding runoff from an increase in impervious surface, development on groundwater recharge areas, drainage impacts associated with new development, and the potential for stormwater capture via sinkholes to impact groundwater quality.

3.10.1 Regulatory Setting

FEDERAL

Clean Water Act

The U.S. Environmental Protection Agency (EPA) is the federal agency primarily responsible for water quality management. The Clean Water Act (CWA) is the primary federal law that governs and authorizes federally mandated water quality control activities by EPA and the states. The CWA provides for the restoration and maintenance of the physical, chemical, and biological integrity of the nation's waters. Various elements of the CWA address water quality, as described below.

CWA Water Quality Criteria/Standards

Pursuant to federal law, EPA has published water quality regulations under Title 40 of the Code of Federal Regulations (CFR). Section 303 of the CWA requires states to adopt water quality standards for all surface waters of the United States. As defined by the act, water quality standards consist of designated beneficial uses of the water body in question and criteria that protect the designated uses. Section 304(a) requires EPA to publish advisory water quality criteria that accurately reflect the latest scientific knowledge on the kind and extent of all effects on health and welfare that may be expected from the presence of pollutants in water. Where multiple uses exist, water quality standards must protect the most sensitive use. As described in the discussion of state regulations below, the State Water Resources Control Board (SWRCB) and its nine regional water quality control boards (RWQCBs) have designated authority in California to identify beneficial uses and adopt applicable water quality objectives.

CWA Section 303(d) Impaired Waters List

Under Section 303(d) of the CWA, states are required to develop lists of water bodies that do not attain water quality objectives after implementation of required levels of treatment by point source dischargers (municipalities and industries). Section 303(d) requires that the state develop a total maximum daily load (TMDL) for each of the listed pollutants. The TMDL is the amount of the pollutant that the water body can receive and still comply with water quality objectives. The TMDL is also a plan to reduce loading of a specific pollutant from various sources to achieve compliance with water quality objectives. In California, implementation of TMDLs is achieved through water quality control plans, known as Basin Plans, of the State RWQCBs. See the state regulatory setting, below, for information on the Central Coast Basin Plan.

National Pollutant Discharge Elimination System

The National Pollutant Discharge Elimination System (NPDES) permit program was established in the CWA to regulate municipal and industrial discharges to surface waters of the United States. NPDES permit regulations have been established for broad categories of discharges including point source waste discharges and nonpoint source stormwater runoff. Each NPDES permit identifies limits on allowable concentrations and mass emissions of pollutants contained in the discharge. Sections 401 and 402 of the CWA contain general requirements regarding NPDES permits.

"Nonpoint source" pollution originates over a wide area rather than from a definable point. Nonpoint source pollution often enters receiving water in the form of surface runoff and is not conveyed by way of pipelines or discrete conveyances. Two types of nonpoint source discharges are controlled by the NPDES program: discharges caused by general construction activities and the general quality of stormwater in municipal stormwater systems. The goal of the NPDES nonpoint source regulations is to improve the quality of stormwater discharged to receiving waters to the maximum extent practicable. The state RWQCBs are responsible for implementing the NPDES permit system.

Federal Antidegradation Policy

The Federal Antidegradation Policy was enacted to provide protection to high-quality water resources of national importance. It directs states to develop and adopt statewide antidegradation policies that include protecting existing instream water uses and maintaining a level of water quality necessary to protect those existing uses and the water quality of high-quality waters. In EPA's CWA regulations regarding water quality standards (40 CFR Chapter 1, Section 131.12[a][3]), the criteria for requiring an antidegradation standard includes the following conditions:

- Existing instream water uses and a level of water quality necessary to maintain those uses shall be maintained and protected.
- Water quality will be maintained and protected in waters that exceed water quality levels necessary for supporting fish, wildlife, and recreational activities, and water quality, unless the state deems that water quality levels can be lowered to accommodate important economic or social development. In these cases, water quality levels can only be lowered to levels that support all existing uses.
- Where high quality waters constitute an outstanding National resource, such as waters of national and state parks and wildlife refuges and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected.

STATE

Porter-Cologne Water Quality Control Act

The Porter-Cologne Water Quality Control Act (Porter-Cologne Act), which is the state's clean water act, provides the statutory authority for State Water Resources Control Board (SWRCB) and the Regional Water Quality Control Boards (RWQCB) to regulate water quality and was amended in 1972 to extend the federal CWA authority to these agencies (see Clean Water Act, above). The Porter-Cologne Act established the SWRCB and divided the state into nine regions, each overseen by a RWQCB. The SWRCB is the primary state agency responsible for protecting the quality of the state's surface and groundwater supplies, but much of the daily implementation of water quality regulations is carried out by the nine RWQCBs.

Under the Porter-Cologne Act, the RWQCB's are given the responsibility and authority to prepare water quality plans for areas within the region (Basin Plans), identify water quality objectives, and issue NPDES permits and Waste Discharge Requirements (WDRs). Water quality objectives are defined as limits or levels of water quality constituents and characteristics established for reasonable protection of beneficial uses or prevention of nuisance. NPDES permits, issued by RWQCBs pursuant to the CWA, also serve as WDRs issued pursuant to the Porter-Cologne Act. WDRs are also issued for discharges that are exempt from the CWA NPDES permitting program, discharges that may affect waters of the state that are not waters of the United States (i.e., groundwater), and/or wastes that may be discharged in a diffused manner. WDRs are established and implemented to achieve the water quality objectives (WQOs) for receiving waters as established in the Basin Plans, as described below. Sometimes they are combined WDRs/NPDES permits.

State Water Resources Control Board

In California, SWRCB has broad authority over water quality control issues for the state. The SWRCB is responsible for developing statewide water quality policy and exercises the powers delegated to the state by the federal government under the CWA. Other state agencies with jurisdiction over water quality regulation in California include the California Department of Health Services (for drinking water regulations), the California Department of Pesticide Regulation, the California Department of Fish and Wildlife (formerly Department of Fish and Game), and the Office of Environmental

Health and Hazard Assessment. Regional authority for planning, permitting, and enforcement is delegated to the nine regional water boards. The regional boards are required to formulate and adopt water quality control plans for all areas in the region and establish water quality objectives in the plans. The Central Coast RWQCB is responsible for the water bodies in the LRDP area.

Central Coast Low Impact Development Initiative

The Central Coast RWQCB established the Low Impact Development Initiative (LIDI) to support healthy watersheds throughout the Central Coast region through the implementation of LID design principles, hydromodification controls, and sustainable development.

Central Coast Basin Plan

The LRDP area is within the jurisdiction of the Central Coast RWQCB (Region 3). The Central Coast RWQCB has the authority to implement water quality protection standards through the issuance of permits for discharges to waters located within its jurisdiction. Beneficial uses of inland surface waters and water quality objectives for the region are specified in the Water Quality Control Plan for the Central Coast Basin (Basin Plan) prepared by the Central Coast RWQCB in compliance with the federal CWA and the state Porter-Cologne Water Quality Control Act. Table 3.10-1 lists the beneficial uses of creeks and other water bodies on or near the LRDP area. The objective of the Basin Plan is to show how the quality of the surface and ground waters in the Central Coast Region should be managed to provide the highest water quality reasonably possible. The RWQCB Board implements the Basin Plan by issuing and enforcing waste discharge requirements (WDRs) to individuals, communities, or businesses whose waste discharges can affect water quality. These requirements can be either State WDRs for discharges to land, or federally delegated permits for discharges to surface water.

Table 3.10-1 Beneficial Uses of Surface Water Bodies on or Near UC Santa Cruz

Water Body	Beneficial Uses in the Basin Plan
Wilder Creek	MUN, AGR, GWR, REC1, REC2, WILD, COLD, WARM, MIGR, SPWN, BIOL, FRESH, COMM
Cave Gulch	MUN, GWR, REC1, REC2, WILD, COLD, WARM, COMM
Moore Creek	MUN, AGR, GWR, REC1, REC2, WILD, COLD, WARM, SPWN, BIOL, FRESH, COMM
San Lorenzo River	MUN, AGR, IND, GWR, REC1, REC2, WILD, COLD, MIGR, SPWN, BIOL, RARE, FRESH, COMM
Antonelli Pond	GWR, REC1, REC2, WILD, WARM, MIGR, SPWN, RARE, COMM

Beneficial Use Definitions: Municipal and Domestic Supply (MUN); Agricultural Supply (AGR); Industrial Service Supply (IND); Ground Water Recharge (GWR); Freshwater Replenishment (FRSH); Water Contact Recreation (REC-1); Non-Contact Water Recreation (REC-2); Commercial and Sport Fishing (COMM); Warm Fresh Water Habitat (WARM); Cold Fresh Water Habitat (COLD); Wildlife Habitat (WILD), Preservation of Biological Habitats of Special Significance (BIOL); Rare, Threatened, or Endangered Species (RARE); Migration of Aquatic Organisms (MIGR); Spawning, Reproduction, and/or Early Development (SPWN).

Source: Central Coast RWQCB 2017

Sustainable Groundwater Management Act of 2014

The Sustainable Groundwater Management Act of 2014 (SGMA)[1] became law on January 1, 2015, and applies to all groundwater basins in the state (Water Code Section 10720.3). By enacting the SGMA, the legislature intended to provide local agencies with the authority and the technical and financial assistance necessary to sustainably manage groundwater within their jurisdiction (CWC Section 10720.1). The SGMA is a follow up to SB X7-6, adopted in November 2009, which mandated a statewide groundwater elevation monitoring program to track seasonal and long-term trends in groundwater elevations in California's groundwater basins. In accordance with this amendment to the CWC, DWR developed the California Statewide Groundwater Elevation Monitoring (CASGEM) program.

[1] The SGMA is comprised of three separate bills: Senate Bill 1168, Senate Bill 1319, and Assembly Bill 1739. All three were signed into law by the Governor on September 16, 2014.

Pursuant to the SGMA, any local agency that has water supply, water management or land use responsibilities within a groundwater basin may elect to be a "groundwater sustainability agency" for that basin (CWC Section 10723). Local agencies had until January 1, 2017 to elect to become or form a groundwater sustainability agency. In the event a basin is not within the management area of a groundwater sustainability agency, the county within which the basin is located will be presumed to be the groundwater sustainability agency for the basin. However, the county may decline to serve in this capacity (CWC Section 19724). The City is currently in the planning stages to partner with other local agencies in compliance with the SGMA.

The SGMA also requires DWR to categorize each groundwater basin in the state as high-, medium-, low-, or very low priority (CWC Sections 10720.7, 10722.4). All basins designated as high- or medium-priority basins must be managed by a groundwater sustainability agency under a groundwater sustainability plan that complies with Water Code Section 10727 et seq. If required to be prepared, groundwater sustainability plans must be prepared by January 31, 2020 for all high- and medium-priority basins that are subject to critical conditions of overdraft, as determined by DWR, or by January 31, 2022 for all other high- and medium-priority basins. In lieu of preparation of a groundwater sustainability plan, a local agency may submit an alternative that complies with the SGMA no later than January 1, 2017 (CWC Section 10733.6). Per the Strategic Groundwater Management Act Data Viewer, DWR has ranked the West Santa Cruz Terrace basin as "very low priority" (DWR 2020). As UC Santa Cruz is not a local agency, it is not eligible to form a groundwater sustainability agency.

NPDES Permits

The SWRCB and RWQCBs, through powers granted by the federal CWA, require specific permits for a variety of activities that have potential to discharge pollutants to waters of the state and adversely affect water quality. To receive an NPDES permit a Notice of Intent (NOI) to discharge must be submitted to the RWQCB and design and operational BMPs must be implemented to reduce the level of contaminated runoff. BMPs can include the development and implementation of regulatory measures (local authority of drainage facility design) various practices, including educational measures (workshops informing public of what impacts result when household chemicals are dumped into storm drains), regulatory measures (local authority of drainage facility design), public policy measures (label storm drain inlets as to impacts of dumping on receiving waters), and structural measures (filter strips, grass swales, and retention basins). All NPDES permits also have inspection, monitoring, and reporting requirements.

General Permit for Storm Water Discharges Associated with Construction Activity

The SWRCB administers the NPDES General Permit for Discharges of Storm Water Runoff Associated with Construction Activity (Construction General Permit). The state requires that projects disturbing more than one acre or more of land during construction file a NOI with the RWQCB to be covered under the General Construction Permit. Construction activities subject to the General Construction Permit include clearing, grading, stockpiling, and excavation.

The Construction General Permit requires that projects develop and implement a Storm Water Pollution Prevention Plan (SWPPP), identifying potential sources of pollution and specifying runoff controls during construction for the purpose of minimizing the discharge of pollutants in storm water from the construction area. The SWPPP must list BMPs the discharger will implement to protect storm water runoff and the placement of those BMPs. Additionally, the SWPPP must contain a visual monitoring program; a chemical monitoring program for "non-visible" pollutants to be implemented if there is a failure of BMPs; and a sediment monitoring plan if the site discharges directly to a water body listed on the 303(d) list for sediment. For projects within the Central Coast Regional Water Quality Control Board jurisdiction, a Storm Water Control Plan documenting the project compliance with the Post-Construction Requirements is also required for entities regulated under the Municipal Separate Storm Sewer System Permit for registration under the Construction General Permit.

<u>General Permit for Storm Water Discharges from Small Municipal Separate Storm Sewer Systems</u>

The Municipal Stormwater Permitting Program regulates stormwater discharges from municipal separate storm sewer systems (MS4s). Stormwater is runoff from rain or snow melt that runs off surfaces such as rooftops, paved streets, highways or parking lots and can carry with it pollutants such as oil, pesticides, herbicides, sediment, trash, bacteria and metals. The runoff can then drain directly into local natural and man-made waterbodies. Often, the runoff drains into storm drains which eventually drain, untreated, into a waterbody.

MS4 permits are issued in two phases: Phase I, for medium and large municipalities, and Phase II for small ones. The Phase II Small MS4 General Permit provides coverage for small municipalities, and covers permittees statewide. The Phase II Small MS4 General Permit requires the discharger to develop and implement best management practices through a coordinated storm water program with the goal of reducing the discharge of pollutants to the maximum extent practicable, which is the performance standard specified in Section 402(p) of the CWA.

The SWRCB designated UC Santa Cruz as a Non-Traditional permittee, which refers to a separate storm sewer system within municipalities such as those related to state prisons, universities, etc. The UC Santa Cruz Storm Water Management Program (UC Santa Cruz SWMP) aims to reduce the discharge of pollutants to the Maximum Extent Practicable, as defined by the US EPA. “Minimum Control Measures” (MCMs) is the term used by the US EPA for the six MS4 program elements aimed at achieving improved water quality through NPDES Phase II requirements. The SWMP ensures that UC Santa Cruz is fulfilling the requirements of its Phase II General Permit for MS4’s. In doing so, the program ensures both legal compliance as well as environmental sustainability systems to protect the water quality.

UNIVERSITY OF CALIFORNIA

UC Santa Cruz Campus Standards Handbook

The UC Santa Cruz Campus Standards Handbook outlines required products and mandatory design constraints for all construction on the campus (UC Santa Cruz 2017). The standards are meant to ensure that UC Santa Cruz constructs functional and durable buildings, based on experience with existing campus buildings. The standards are complementary to project-specific requirements and can be modified, as necessary, at the discretion of the UC Santa Cruz project manager based on site-specific conditions. UC Santa Cruz requires:

- review of schematic, design development, 50 percent, 100 percent construction documents, and 100 percent backcheck submittals;
- compliance with federal, State, and regional codes or acts; in the case of conflict between codes, the more stringent code conditions apply;
- soil investigation reports, as necessary, for projects;
- site survey information;
- consultation with the Design Advisory Board, normally at the beginning of schematic design, midway through schematic design, and midway through design development;
- review by the Campus Physical Planning Advisory Committee after the end of schematic design;
- design review approval for applicable projects by the UC Regents;
- review and approval by the State Fire Marshal and Division of the State Architect at construction document completion;
- approval of completed design development documents by the State Public Works Board for major State-funded projects;
- independent reviews are required by the UC Regents for cost, design, and seismic safety; and
- design compliance with current LRDP EIR mitigation measures and any project-specific mitigation measures.

UC Santa Cruz Storm Water Management Program

The UC Santa Cruz SWMP, last updated in 2014, was developed and is implemented by UC Santa Cruz in compliance with the SWRCB Phase II NPDES requirements. The intent of the UC Santa Cruz SWMP is to facilitate comprehensive management of storm water quality and to subsequently enhance UC Santa Cruz's environmental stewardship. The UC Santa Cruz SWMP covers the LRDP area (main residential campus and Westside Research Park at2300 Delaware, as well as UC Monterey Bay Education Science and Technology (MBEST) Center and the Coastal Science Campus; identifies constituents of concern (COC), sources, or activities that would have the potential to discharge a COC into runoff; and identifies best management practices to be implemented to address the COC.

UC Santa Cruz Post-Construction Stormwater Management Requirements

The UC Santa Cruz Post-Construction Stormwater Management Requirements (UC Santa Cruz Post-Construction Requirements), last updated in March 2017, are in compliance with Central Coast Regional Water Quality Control Board Resolution No. R3-2013-0032. The UC Santa Cruz Post-Construction Requirements are incorporated into the Stormwater Management Program. The document divides the main residential campus into four watershed management zones based on geologic conditions, slope, and other factors; defines regulated projects as including new development and redevelopment projects that would create or replace more than 2,500 square feet of impervious surface over a project site, and sets forth a series of performance requirements related to site design and runoff reduction; water quality treatment; stormwater control plan requirements; runoff retention; LID development standards; and peak flow management. The UC Santa Cruz Post-Construction Requirements emphasize protecting and, where degraded, restoring key watershed processes to create and sustain linkages between hydrology, channel geomorphology, and biological health necessary for healthy watersheds. Maintenance and restoration of watershed processes impacted by storm water management is necessary to protect water quality and beneficial uses. All regulated projects on the main residential campus are required to comply with the requirements set forth in this document. The specific performance requirements for runoff reduction, water quality treatment, and peak flow management, depend on the size of the project and within which watershed management zone the project is located (UC Santa Cruz 2016).

Generally, projects in all watershed management zones that add or replace more than 5,000 square feet of impervious surface, must provide storm water treatment systems that treat the volume of runoff generated by the 85th percentile 24-hour storm, with specific performance requirements for low impact development systems, biofiltration treatment systems, and non-retention-based systems such as engineered treatment systems. Retention requirements are based on the watershed management zones. All runoff from the 85th or 95th percentile 24-hour rainfall event must be retained on site via storage, rainwater harvesting, infiltration, and/or evapotranspiration. In addition, post-development peak flows may not exceed pre-project flows for the 2- through 10-year storm event.

LOCAL

As noted in Section 3.0.1, "University of California Autonomy," UC Santa Cruz, a constitutionally created State entity, is not subject to municipal regulations of surrounding local governments for uses on property owned or controlled by UC Santa Cruz that are in furtherance of the university's educational purposes. However, UC Santa Cruz may consider, for coordination purposes, aspects of local plans and policies of the communities surrounding UC Santa Cruz when it is appropriate and feasible, but it is not bound by those plans and policies in its planning efforts.

County of Santa Cruz General Plan

The County of Santa Cruz General Plan (1994) contains the following policies related to hydrology and water quality in the county and that may be relevant to the 2021 LRDP:

- Policy 7.18.5 Groundwater Management. Promote water management in the Pajaro Valley and Santa Margarita groundwater basins and the Soquel-Aptos area to protect the long-term security of water supplies and to safeguard groundwater quality and maintain stream baseflows.

City of Santa Cruz General Plan

The City of Santa Cruz General Plan (2012) contains the following policies related to hydrology and water quality in the city and that may be relevant to the 2021 LRDP:

- **Policy CC3.3** Safeguard existing surface and groundwater sources.
- **Policy CC3.4** Maintain and improve the integrity of the water system.
- **Policy CC4.1** Provide an adequate and environmentally sound wastewater collection, treatment, and disposal system.

3.10.2 Environmental Setting

STUDY AREA

The study area for the evaluation of impacts on hydrology and water quality consists of all watersheds that originate on the main residential campus and the Westside Research Park (see Table 3.10-2 below for a list of campus watersheds). For groundwater impacts, the study area includes the LRDP area and portions of the city of Santa Cruz between the LRDP area and the coastline (see Figure 3.10-1).

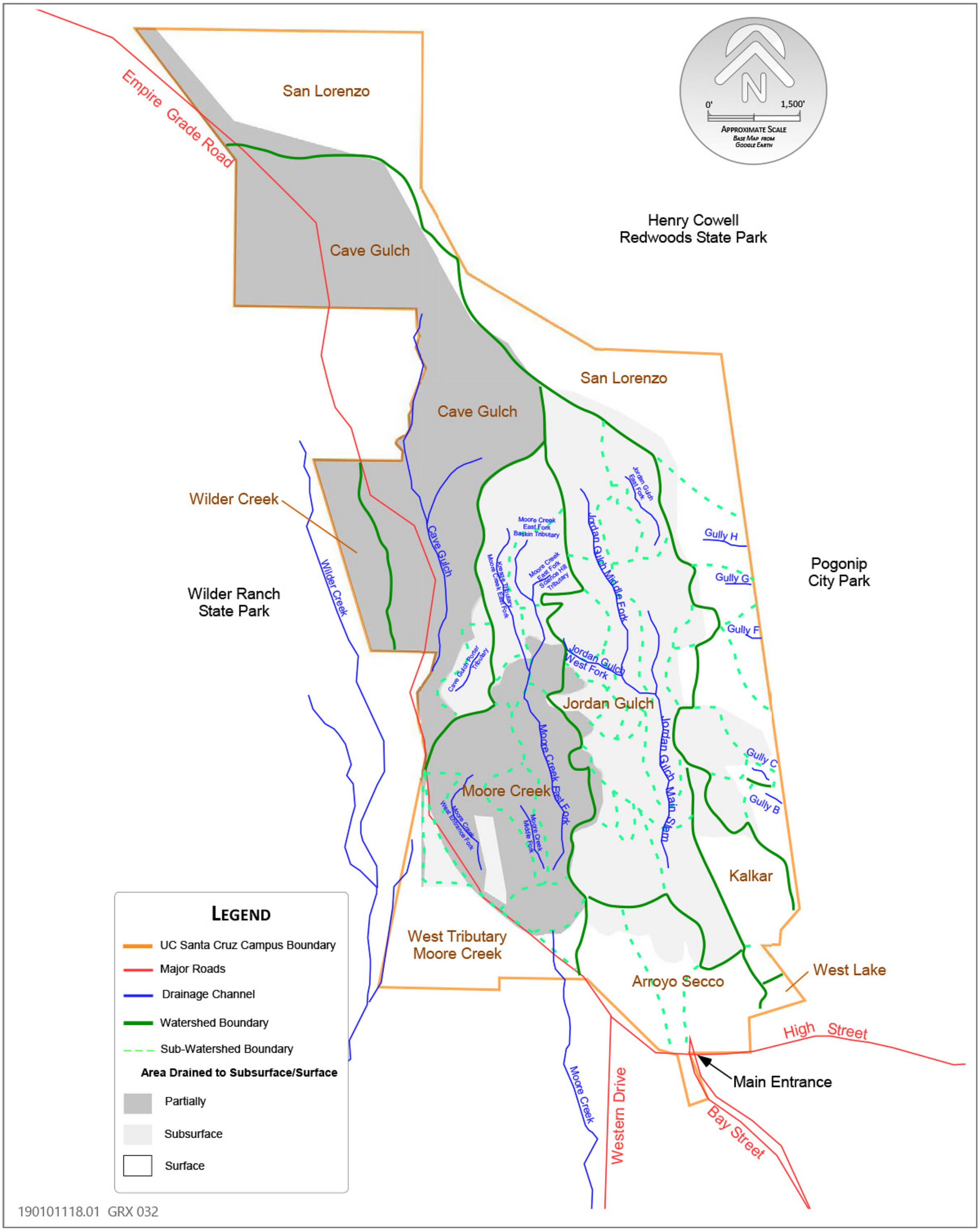
Table 3.10-2 Watersheds on the LRDP Project Area

Watershed	Total Area (acres)	On-Campus (approximate acreage)	Area on-Campus as Percent of Total	Subsurface (acres)	Partial Subsurface (acres)	Surface Drainage (acres)	Number of Subsurface-Drained Sub-watersheds
Wilder Creek	2,830	45	16%	0	49	0	1
Cave Gulch	630	466	74%	25	440	0	4
Moore Creek	905	272	30%	104	141	9	15
Moore Creek Western Tributary	335	112	33%	12	0	100	1
Jordan Gulch	442	442	100%	364	66	13	20+
Arroyo Seco	665	121	18%	23	0	98	2
High Street	60	6	10%	0	0	6	0
Kalkar Quarry	65	62	97%	9	0	53	1
San Lorenzo River	74,000	522	0.7%	51	0	471	6
Total				**588**	**696**	**750**	**50**

Overview Main Residential Campus

The main residential campus is situated on hilly terrain as a series of upward sloping marine terraces from an elevation of approximately 300 feet at its southern boundary to approximately 1,200 feet along its northwest boundary. The terrain is incised by steep natural drainage channels which include gulches and coastal canyons.

The northern one-third of the main residential campus is comprised primarily of weathered schist and granitic rocks overlain in some areas by nearly flat-lying, weathered Santa Margarita sandstone. Surface flows in these areas are dispersed and the geology of the area supports percolation of precipitation before eventually gathering in well-defined drainages.



Source: Figure produced and provided by Weber, Hayes & Associates in 2020

Figure 3.10-1 Watersheds and Sub-Basins on UC Santa Cruz Campus

The southern two-thirds of the main residential campus consist of marble, granite and schist bedrock overlain by deposits of residual soils and colluvium, where karst topography has developed as a result of the dissolution of marble. While this portion of the main residential campus is cut by several steep-walled north-south flowing stream channels, an integrated drainage system is not present due to sporadic stream capture by sinkholes and swallow holes (i.e., the location in karst limestone at which surface water is channeled to the subsurface). Most storm water on campus eventually reaches the karst aquifer, where it flows through a complex system of solution channels (i.e., fractures through which water may flow) and caves. Some of the runoff reappears at the surface as springs at lower elevations to the east, south, and west of the main residential campus (Johnson and Weber & Associates 1989).

On account of steep gradients and the presence of fractured rocks and soils highly susceptible to erosion, the potential for erosion by storm water runoff is generally high on the central and north campus. Furthermore, the potential for erosion on the central and lower campus has been exacerbated by the addition of impervious surfaces as the central campus has developed over the years.

There is no campus-wide storm drain system. Within the developed portions of the main residential campus, storm drains have been installed to capture local runoff and convey it to natural areas. Flow rates are reduced through detention basins and underground detention vaults. After detention, the runoff is discharged into the nearest drainage channel or dissipated for infiltration in open grasslands or other undeveloped land. However, runoff from some older development is discharged to drainage channels without detention.

Westside Research Park

The Westside Research Park is situated on a portion of the gently southward sloping, lowest (i.e., youngest) emergent marine terrace, a common landform along the California coastline that reflects changes in sea levels. The site ranges in elevation from approximately 70 feet at its northern boundary to approximately 55 feet at its southern boundary along Delaware Avenue, and is bounded to the west by Antonelli Pond. The Land Trust of Santa Cruz County owns and is responsible for the management and restoration of Antonelli Pond and the lower Moore Creek Corridor (Land Trust of Santa Cruz 2020). The surficial materials beneath the site consist of Quaternary coastal terrace deposits comprised of predominantly fine to coarse-grained sand and fine gravel, with varying fractions of silt and clay. Extensive subsurface investigative work completed at a nearby chemical release site (411 Swift Street, located approximately 2,200 feet east of the site) documents the thickness of the terrace deposits to range from 7 to 12.5 feet below the ground surface (bgs) where shallow bedrock is encountered (Trinity Source Group 2018). Shallow groundwater that is encountered above the bedrock contact has been documented to range from depths of 4 to 10 feet bgs. The bedrock underlying the coastal terrace deposits is the Santa Cruz Mudstone. The bedrock unit consists of siliceous mudstone and sandy siltstone.

Stormwater runoff is captured through a network of drain inlets and conveyed to the City of Santa Cruz storm sewer system. A portion of the runoff is also conveyed to Antonelli Pond. Shallow groundwater conditions at the site present constraints for surface water percolation.

SURFACE WATER RESOURCES

Surface Water Hydrology Precipitation and Evapotranspiration

Rainfall levels vary considerably with elevation; the lower campus receives an average of approximately 30 inches of rainfall annually, while the north campus receives approximately 40 to 45 inches or more (Johnson and Weber & Associates 1989). Average evapotranspiration is estimated to be 19.7 inches per year (Johnson and Weber & Associates 1989). Average annual rainfall on the main residential campus is approximately 41.4 inches based on the stormwater tool to estimate load reductions (TELR) (Beck et al. 2017) modeling calculations for various 24-hr precipitation depths and the average annual number of days with measurable precipitation to represent the overall distribution and total average annual depths. The rainfall estimates were obtained from the PRISM Climate Group (2004) at Oregon State University (2NDNATURE 2020).

WATERSHEDS

The main residential campus and Westside Research Park are located within the Big Basin Hydrologic Unit, as defined by the Central Coast RWQCB. The main residential campus is drained through both surface and subsurface drainages by watersheds that originate within the main residential campus boundaries. The assignment of surface water runoff to a particular watershed is based on topographic features of the main residential campus; however, flows captured by the natural subsurface karst aquifer drainage system or by the UC Santa Cruz storm water drainage system may be transferred from one watershed to another in some cases.

Three watersheds, Cave Gulch, Moore Creek and Jordan Gulch, drain approximately 1,275 acres in the northern and central portions of the main residential campus. All three stream channels are generally aligned north-south and controlled by the major geologic fracture systems on the main residential campus. Cave Gulch, which drains mainly the undeveloped northwestern portions of the main residential campus, joins Wilder Creek immediately west of the main residential campus. Moore Creek, which drains the central and western portions of the main residential campus, flows in a southwesterly direction and ultimately discharges into Antonelli Pond near the coast. Jordan Gulch drains the central and eastern portions of the main residential campus and much of the developed campus core and continues as a spring-fed channel down Bay Street (Figure 3.10-1).

As noted above, as a result of the karst geomorphology of the central and lower campus, several of the tributaries of the main residential campus drainages do not discharge into the main channels but instead discharge into in-stream swallow holes. Flow in the two main drainages on the main residential campus, Moore Creek and Jordan Gulch, is captured by swallow holes in the lower campus. The karst features intercept most of the surface flow, even during extreme rainfall events. As a result, surface runoff from the main residential campus is usually low overall compared to other areas with similar rainfall (Johnson and Weber Associates 1989).

Areas of the main residential campus not drained by the three major watersheds are drained by a number of creeks and gullies that originate along the campus boundary. Much of the western boundary of the main residential campus, including portions of the north campus, is drained by Cave Gulch and Wilder Creek. Four small drainages occur along the southern campus boundary. From west to east these include: a western tributary of Moore Creek that discharges to Moore Creek downstream from the main residential campus boundary; the headwaters of Arroyo Seco, a canyon east of Western Drive; hillslope drainage onto High Street; and drainage into Kalkar Quarry Pond (a spring-fed pond occupying a former marble quarry). The northeastern and eastern boundary of the main residential campus is drained mainly by a series of hillslope drainages within the San Lorenzo River watershed (Johnson 2003).

The drainage areas of the LRDP area watersheds are shown in Table 3.10-2. The Westside Research Park is located within the Moore Creek Watershed. Each of the major watersheds are described below. There are nine principal watersheds and more than 50 sub watersheds drained by individual sinkholes and swallow holes.

Based on the locations of known sinkholes and swallow holes, campus watersheds have been divided into portions having partial or complete subsurface drainage as shown in Figure 3.10-1.

Wilder Creek Watershed

Wilder Creek has a watershed of approximately 2,830 acres. About 45 acres of Wilder Creek watershed is located in western portion of the main residential campus. A large spring, Wilder Creek Spring, outcrops in the creek west of the main residential campus approximately 100 yards upstream of the Cave Gulch confluence. This spring likely discharges some of the water originating from the subsurface drainage underlying the main residential campus. Upstream from the Wilder Creek Spring, much of the stream flow drains underground through swallow holes in the streambed (Johnson and Weber & Associates 1989). During the drier months, streamflow in Wilder Creek percolates into permeable alluvium and sandstone before reaching Highway 1 (Johnson 1988).

Cave Gulch Watershed

The western and northwestern portions of the main residential campus drain to the Cave Gulch watershed, a tributary basin to the Wilder Creek watershed and is the largest watershed draining campus. The on-campus drainage area of Cave Gulch is about 466 acres, which is about 74 percent of the total watershed of this drainage. The on-campus portions of the Cave Gulch system are steep to moderately steep with channel gradients ranging from roughly 1 to 10 percent (Kennedy/Jenks Consultants 2004).

There are two main tributaries to Cave Gulch on the main residential campus. The Porter Tributary is located immediately downslope of the Porter Infill Apartments and to the west of the Family Student Housing complex and drains approximately 30 acres. Two sinkholes located near Family Student Housing capture runoff from the Porter Tributary. The Pump Station Tributary is located approximately one mile north of the west entrance to the main residential campus on Empire Grade and receives runoff from an inboard ditch along Empire Grade that is several thousand feet in length (Kennedy/Jenks Consultants 2004).

In general, campus lands that presently discharge into the Cave Gulch drainage system are largely undeveloped and contain only a few service roads used for recreation and emergency vehicles access and a 1-million gallon water tank. The few developed areas within the watershed are a portion of the Trailer Park, the western half of Kresge and Porter Colleges, and a portion of Family Student Housing complex. Erosion conditions have been documented within the watershed, associated mainly with the Pump Station Tributary and the Porter Tributary (Kennedy/Jenks Consultants 2004).

Moore Creek Watershed

The Moore Creek watershed is the third largest watershed within the core campus area and has a drainage area of about 905 acres above Antonelli Pond, which is located in the city of Santa Cruz. Approximately 384 acres of the drainage area are located on the LRDP area, including the Moore Creek Western Tributary. On the main residential campus, the watershed extends from the northern portions of the main residential campus, north of Baskin Engineering, to the southern boundary just beyond the Arboretum Dam. The Moore Creek drainage system consists of the main stem and several tributaries. The East Fork Baskin and Science Hill tributaries drain the northwestern portions of the Science Hill area of the main residential campus, including portions of the Baskin Engineering buildings, the Natural Sciences Unit II building, the Physical Sciences building, and the core west parking structure. The East Fork Kresge Tributary drains the area between Kresge College and Heller Drive. Both the East Fork Kresge Tributary and the East Fork Baskin Tributary terminate at sinkholes (the Kresge Tributary Sinkhole and the Baskin Tributary Sinkhole, respectively) and discharge into the Moore Creek main stem only when the sinkholes overflow (Kennedy/Jenks Consultants 2004).

The head of the Moore Creek East Fork is located just west of University House and drains the central and south portion of campus from Meyer Drive south to the Arboretum Dam. The primary campus developments contributing runoff include Rachel Carson College Apartments, Performing Arts, southeast portion of Porter College, University House and the eastern portion of Oakes College. The East Dam forms the lower end of the East Fork of Moore Creek where a sinkhole is present. The East Dam has never been documented to spill during flood events but reportedly came very close to doing so during the 1982 storms (UCSC 2006). Spilling during the 1982 storms was averted due to the opening of two sinkholes located behind the dam within the reservoir (Kennedy/Jenks Consultants 2004).

Moore Creek Middle Fork originates south of Oakes College and to the west of West Remote parking lot and also flows into the Arboretum Pond. The lowest on-campus tributary is the West Entrance Fork that originates just south of the intersection of Koshland Way and Heller Drive and flows in a southerly direction to the West Dam (see Figure 3.10-1). The West Dam is likely a relic feature from the late 1800s and early to mid-1900s when the City of Santa Cruz constructed the Arboretum Dam to store water from their North Coast water supply. A sinkhole is present in this channel just upstream of the West Dam. The East and West dams were constructed upstream of the Arboretum Dam and were intended to serve as sediment catch basins above the reservoir and/or to provide additional storage capacity. The use of the Arboretum Pond for water supply was abandoned in 1948 after the City determined that up to 750,000 gallons of water per day were being lost to the subsurface due to the presence of sinkholes in the channel of Moore Creek and the West Entrance Fork (UCSC 2006). All three dams on Moore Creek are earthen embankment dams. The East and West dams do not have spillways, although a 30-inch pipe was installed in the West Dam to serve as a spillway for excess flows. Originally the Arboretum Dam did not have a spillway and the dam only released discharge through a 14-inch pipe installed through the base of the dam. In 2001, a 4-foot diameter pipe was installed below the dam crest to act as a spillway (UCSC 2006). Both the 4-foot spillway pipe and the 14-inch outlet pipe discharge to a culvert under Empire Grade that carries runoff to Moore Creek.

The total area of Moore Creek watershed above the Arboretum Dam is about 305 acres, but about 100 acres of this drainage area drains directly to the subsurface at locations upstream of the dam (UCSC 2006). The impounded water drains through the pipe at the base of the dam, via the subsurface, and via leakages through burrows in the dam faces. Typically, water remains in the Arboretum Pond well into the dry season (UCSC 2006). The Arboretum Pond and the two basins created by the East and West Dams have a reported combined capacity of about 35 acre-feet below the elevation of the Arboretum Dam spillway pipe, the West Dam outlet, and the crest of the East Dam. This capacity is large enough to contain runoff from a 50-year storm if all existing sinkholes are plugged, or a 100-year storm if the existing sinkholes remain open (Rutherford & Chekene 1992, cited in UC Santa Cruz 2005).

Approximately 15 acres of the main residential campus lands south of the Arboretum Dam drain directly into Moore Creek south of the main residential campus.

Channel conditions in the Moore Creek watershed as documented in the Stormwater and Drainage Master Plan (Kennedy/Jenks Consultants 2004) vary from fair to bad. Moore Creek contained the most severe in-channel conditions on the main residential campus with the Main Stem and West Entrance Fork were documented to be in particularly poor condition. Erosion features within the Moore Creek watershed consisted of actively migrating knickpoints, eroding channel banks, minor slope failures, loss of near-channel vegetation, and channel incision (Kennedy/Jenks Consultants 2004). These erosion conditions result from a number of factors including the natural erosion process, increased runoff due to impervious surfaces and partly as a result of pedestrian and bicycle use of trails along creek banks. The Baskin and Kresge sinkholes were documented to be at or close to capacity (Kennedy/Jenks Consultants 2004), at the time of the study. It is important to note, however, that in-channel sinkholes episodically change their capacity to infiltrate stormwater runoff due to erratic cycles of collapse and infill.

Jordan Gulch Watershed

The Jordan Gulch watershed is the second largest watershed on the main residential campus with a drainage area of approximately 1,350 acres, of which 442 acres are within the LRDP area. The watershed extends from the northern portions of campus, north of Colleges Nine and Ten, south to the lower portions of campus near the main entrance.

Several critical sinkholes break-up the Jordan Gulch watershed into sub-watersheds and include the McLaughlin Drive Sinkhole (also known as the Chinquapin Sinkhole), Middle Fork Sinkhole, Upper Quarry Sinkhole, McHenry Library Sinkhole, and the Lower Quarry Sinkhole. These sinkholes capture runoff from upper campus and as a result, almost all the water in the Jordan Gulch watershed enters the subsurface drainage system. Failure of these sinkholes to effectively capture runoff during storm events would result in increasing impacts in downstream reaches.

Jordan Gulch East Fork drains an approximate 30-acre area and extends from the Spring Trail Road, north of Colleges 9 and 10, south to McLaughlin drive where it terminates in McLaughlin Sinkhole. This sub-watershed receives concentrated stormwater runoff from Fuel Break Road, Chinquapin Road, Spring Road and lesser volumes from Colleges 9 and 10.

Jordan Gulch Middle Fork drains an approximate 85-acre area which extends from the area west of College Nine near Spring Road and flows south in a relatively deep canyon to its confluence with the Jordan Gulch main stem just west of the East Field area. This sub-watershed receives concentrated stormwater runoff from Colleges 9 and 10 and are also are fed by springs in the north campus.

Jordan Gulch West Fork drains an approximate 24-acre area within the central portion of campus located around McHenry Library, the Center for Adaptive Optics, Thimann Lab, Clark Kerr Hall, the Academic Resources Center, and the Baskin Arts Center. This sub-watershed receives concentrated runoff from these locations.

Jordan Gulch Main Stem drains an approximate 215-acre area and extends from the Bay Tree Bookstore and continues south in a deeply incised canyon where it terminates in two sinkholes just north of the Lower Quarry. South of the Lower Quarry, it continues down to the area just west of the Hagar Drive/Glenn Coolidge Drive intersection. This sub-watershed receives a mix of detained and undetailed stormwater from the Bay Tree Bookstore, Cowell

College, East Field House Complex and the Humanities building. The Humanities building also has a historic sinkhole on site that takes predevelopment runoff volumes from the site. Runoff in excess of predevelopment volumes is detained and released into the mainstem of Jordan Gulch. The lower mainstem also receives stormwater runoff from the lower west fork and middle forks of Jordan Gulch (Kennedy/Jenks Consultants 2004).

Jordan Gulch Great Meadow Tributary drains an approximate 39-acre area extending from the Music Facilities, south-southeast to the Lower Quarry and Village Housing complex. This sub-watershed primarily receives runoff from portions of Baskin Art, the Music Performance Hall, and associated buildings and parking lots. The development and enlargement of several sinkholes along the Great Meadow Tributary occurring in the 1990s have been documented (Kennedy/Jenks Consultants 2004).

Channel conditions in the Jordan Gulch watershed as documented in in the *Stormwater and Drainage Master Plan* (Kennedy/Jenks Consultants 2004) in general are "better" than the conditions in the Moore Creek watershed. The McLaughlin Drive and Middle Fork sinkholes were documented to be at or close to capacity (Kennedy/Jenks Consultants 2004). Stretches of those drainages that are underlain by active and "dormant" sinkholes may, however, change their capacity to infiltrate stormwater runoff in the future as the sinkholes collapse or become infilled with sediment. Storm water drainage improvements were proposed for this watershed under the Infrastructure Improvements Project. Since 2005, the main residential campus has been implementing this phased infrastructure improvement program. Projects completed for this watershed are discussed in Section 3.10.5.

San Lorenzo – Pogonip Watershed

The San Lorenzo – Pogonip watershed has a combined total drainage area of approximately 520 acres on the main residential campus. In general, the San Lorenzo – Pogonip watershed drains much of the eastern portion of the main residential campus east of Hagar Drive from north of the Crown-Merrill Apartments south to the southern boundary of the campus and boarders the City of Santa Cruz' Pogonip Park to the east of campus. Eight sub watersheds comprise the larger area that are associated with a number of west-east trending gullies (Gullies A through H) that drain to the east (see Figure 3.10-1). Several sinkholes are documented within this area, including a primary sinkhole with Gully B that receives runoff from the East Remote parking lot (Kennedy/Jenks Consultants 2004). At least one sinkhole beneath the Lower East Field was previously covered to facilitate development (Johnson 2003).

Channel conditions in the San Lorenzo–Pogonip watershed vary from location to location but are in general fair to poor. Steep channel gradients, erosive soils and burrowing animals contribute to erosion conditions in Gullies F and B, and concentrated runoff contributes to erosion conditions in Gullies H and G. Gully B is located approximately 800 feet southeast of the East Remote parking lot and receives storm water via a culvert that captures roadway runoff along the west side of Glenn Coolidge Drive and channels it to the head of this gully. Approximately 10 acres of campus land drains into Gully B; however approximately 3 acres may drain to a covered sinkhole beneath the Lower East Field. Most of Gully B is undeveloped with the exception of an approximate ½ acre area that is covered by Glenn Coolidge Drive, a County-owned and maintained roadway. Previously documented erosion sites in the gully are situated downstream of four wooden check dams built by the City in the Pogonip. Gully F is located directly east of the East Field, and drains to the southeast before crossing under Glenn Coolidge Drive. The drainage area of Gully F on the main residential campus is approximately 37 acres. This gully receives un-detained water from the southern portion of Stevenson College, the East Field, and some length of Glenn Coolidge Drive. Concentrated stormwater runoff is the likely cause of erosion problems documented within this gully on campus lands. Gully G is located at the north end of Glenn Coolidge Drive where is turns west becomes McLaughlin Drive. Its on-campus drainage area is approximately 19 acres. Portions of Stevenson, Crown and Merrill Colleges, Stevenson College parking lots and portions of McLaughlin Drive contribute runoff to this gully. This gully is deeply incised to the east of Glenn Coolidge Drive and has experienced several channel bank failures. Concentrated runoff from impervious surfaces is likely the source of erosion conditions in this gully. A large detention vault was recently installed beneath the Stevenson College East Parking lot to address this issue. Recent inspections confirm the drainage area on campus has since stabilized. Gully H is located in the northeastern corner of the campus with an on-campus drainage area of approximately 40 acres. Existing UC Santa Cruz development that contributes runoff to this gully includes Crown-Merrill Apartments, Crown College and three large parking lots. The erosion conditions previously documented in this gully include actively migrating knickpoints, incised channel, and eroding slope gullies. Concentrated runoff is the primary cause of these conditions (Kennedy/Jenks Consultants 2004).

Other Local Drainages

The far southwestern extent of the main residential campus west of Empire Grade has low relief and lacks a well-defined drainage pattern. The central and eastern portions of this area drain into a western tributary of Moore Creek.

Arroyo Seco is a canyon located south of Meder Street and east of Western Drive. The upper 120 acres of the Arroyo Seco watershed are located on campus south of Jordan Gulch and east of Moore Creek. Surface runoff from approximately 98 acres near the main entrance of the main residential campus leaves the area as overland flow and joins Bay Creek south of the main residential campus. From this point, the creek, Bay Creek, continues down in the median of Bay Street as a spring-fed perennial (year-round), partially culverted stream to Neary Lagoon.

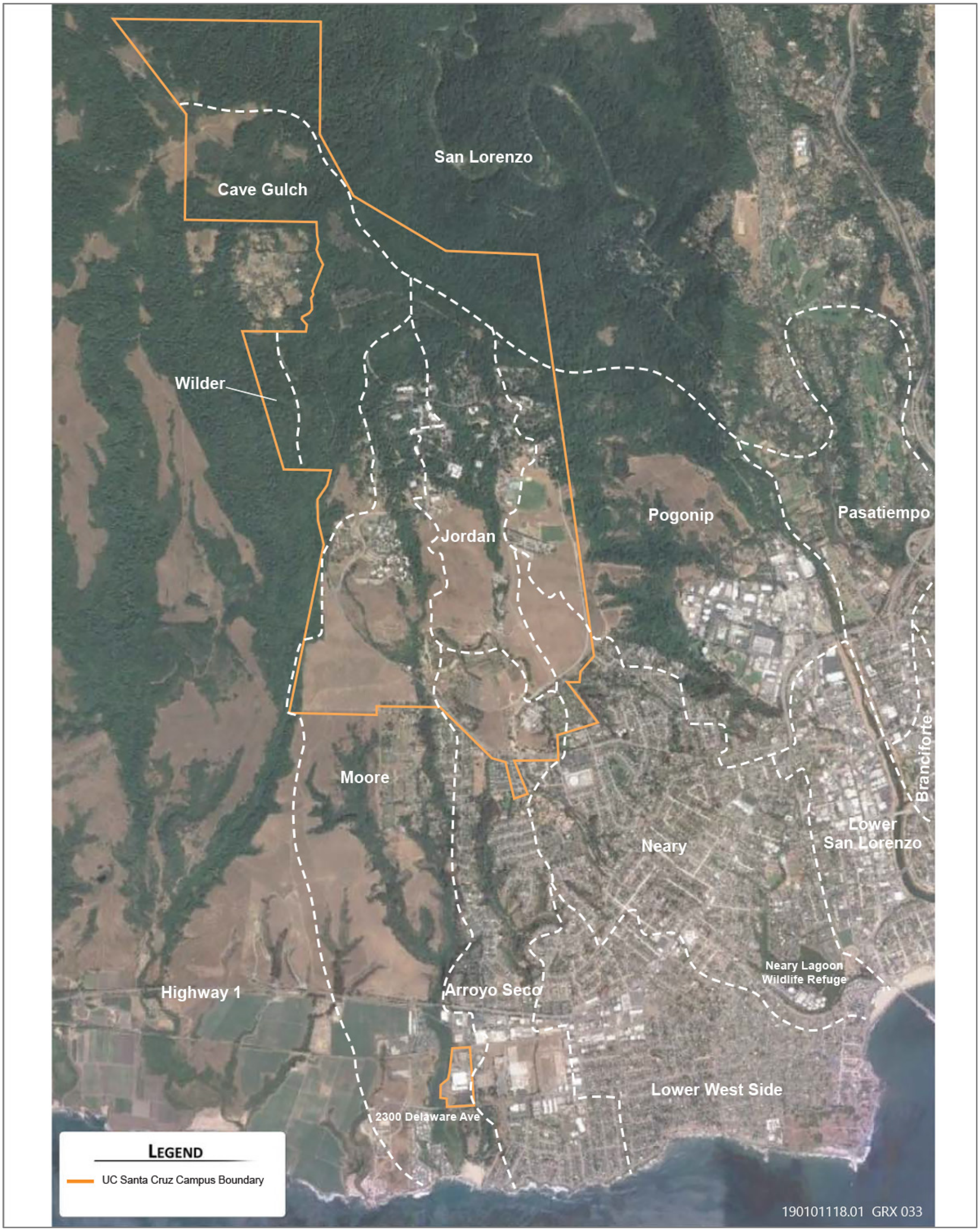
Kalkar Quarry is a historic marble quarry just east of the main residential campus near the intersection of Hagar Drive/Glenn Coolidge Drive, which has developed a pond that is fed by an underlying spring and by a series of culverts that drain the south-eastern portion of the main residential campus, including a portion of the Faculty Housing area (UCSC 2006).

WATERSHEDS SURROUNDING THE LRDP AREA

Watersheds surrounding the main residential campus and Westside Research Park are shown on Figure 3.10-2. The northwest portion of the main residential campus along the Ben Lomond Mountain ridge is bordered to the north and northeast by the San Lorenzo River watershed and the Gold Gulch drainage subarea. Bordering the main residential campus to the east are the Pogonip and Arroyo de San Pedro Regaldo drainage subareas of the San Lorenzo River watershed. The San Lorenzo River drains to the Pacific Ocean approximately 2.2 miles southeast of the main residential campus. Of the total San Lorenzo River watershed area of about 74,000 acres, only an area of approximately 520 acres drains from the campus itself.

To the southeast of the main residential campus are the watersheds of Kalkar Quarry, which is also known as Ojos de Agua (65 acres total, with over 97 percent on campus) and High Street (60 acres total, with only about 10 percent on campus). These two watersheds are subareas of the Jordan Gulch/Neary Lagoon watershed with outflow to Neary Lagoon on the coastal plain. Of the total 1,350 acres of the Jordan Gulch/Neary Lagoon watershed, approximately 400 acres that are located on the main residential campus drain to the subsurface through karst sinkholes. About 13 acres of the on-campus portion of the Jordan Gulch watershed drain to the surface south of the main residential campus, where the Jordan Gulch drainage continues south along Bay Street as a spring-fed channel (Bay Creek) toward Neary Lagoon. To the south of the main residential campus and further west are the Arroyo Seco watershed (665 acres total with approximately 120 acres on campus) and the Moore Creek watershed, including the West Tributary Moore Creek subarea (1,240 acres total with approximately 400 acres on campus). Moore Creek discharges to Antonelli Pond before reaching the Pacific Ocean at Natural Bridges State Beach. Arroyo Seco discharges to the Pacific Ocean just east of Natural Bridges State Beach (UCSC 2006).

Most of the northwest portion of the main residential campus along the Ben Lomond Mountain ridge, is bordered to the northwest and west by the headwaters of Wilder Creek, Peasley Gulch, Baldwin Creek, and Majors Creek. Bordering the west side of the main residential campus are the lower Wilder Creek watershed and Cave Gulch watershed (Johnson 1988 & 1989). Wilder Creek drains into the Pacific Ocean approximately 2 miles southwest of the main residential campus (UCSC 2006).



Source: Figure produced and provided by Weber, Hayes & Associates in 2020

Figure 3.10-2 Watersheds in the Greater Vicinity of UC Santa Cruz Campus

EROSION

As discussed in Section 3.7, Geology and Soils, specifically Table 3.7-2 and Figure 3.7-5, large portions of the north campus contain soils with a slight to moderate erosion potential, and significant pockets of soils with a high to very high erosion potential are present in the upper, central, and lower areas of the main residential campus. The Westside Research Park contains soils with a slight to moderate erosion potential. The portion of the main residential campus underlain by karst is pockmarked with dolines (or sinkholes), with some of the sinkholes present in the drainages (i.e., swallow holes). Erosion, sedimentation, and infiltration, both natural and man-made, can have complex interactions. Some sinkholes have been filled by infiltration of fine-grained sediments or by wall collapse, which can exacerbate erosion problems. In other locations, the sinkholes have actually enlarged and capture almost all of the sediment and a portion or all of the drainage water, resulting in very little erosion downstream.

In 2004, UC Santa Cruz prepared a Stormwater and Drainage Master Plan (Stormwater Plan) as a comprehensive and definitive document for planning improvements to the UC Santa Cruz storm water drainage system (Kennedy/Jenks Consultants 2004). Development of the Stormwater Plan also addressed Best Management Practices (BMPs) to improve the water quality of the stormwater and focused on human-caused erosion, because this type of erosion is generally the easiest to control or prevent. The Stormwater Plan notes that natural factors or events can also cause erosion, and not all the erosion occurring on campus is caused by human activity. The Stormwater Plan developed a list of prioritized, in-channel and out of channel improvement projects for implementation to address deficiencies in the existing systems. The proposed projects were designed to improve the natural drainage channels through upstream reductions in flows (through infiltration, dispersion, detention, and/or retention) and in-channel stabilization, armoring, and repair. These recommended improvement projects were incorporated into UC Santa Cruz Infrastructure Improvements Project (2005 LRDP DEIR, Volume 3, Chapter 2) for implementation. Specifically, the focus of Phase 1 improvements was to reduce flows in those sections of the drainages that were experiencing severe erosion by diverting, dispersing and detaining runoff in the upper portions of the watersheds. The focus of Phase 2 improvements was in-channel stabilization, armoring, and repair. The improvements were identified for four drainages on the main residential campus – Cave Gulch, Moore Creek, Jordan Gulch, and some of the gullies that flow into the Pogonip-San Lorenzo watershed. The implementation of the Infrastructure Improvements Project would alter drainage patterns but would not result in increased flooding on or off site (Kennedy/Jenks Consultants 2004).

Since 2005, UC Santa Cruz has been implementing this phased infrastructure improvement program. To date, completed Phase 1 improvement projects are included in Table 3.10-3.

Phase 2 improvement projects began in July 2013 and the initial groundwork (e.g., grading, planting, placing of rock, etc.) was completed in October 2014. These improvement projects focused on the Baskin, Science Hill and East Fork Reach tributaries of Moore Creek and the East Fork, Mainstem Upstream Reach and Downstream Reach of Jordan Gulch. In general, infrastructure improvements included the installation of log drop structures, rock step pools, sediment excavation, installation of a biotechnical debris dam and check dams, installation of rock step pools, rock sills, log drops, board check dams, excavation of sediment in limited areas, re-contouring of banks, minor grading associated with these features, and re-vegetation.

At the request of the US Army Corps of Engineers (USACE) and the Central Coast RWQCB, Huffman-Broadway Group, Inc. (HBG) along with UC Santa Cruz staff conducted annual assessments of post-restoration habitat and structural conditions using the California Rapid Assessment Method (CRAM). The purpose of the Post-Restoration CRAM study was to assess the performance of the stream restoration efforts to obtain data that will aid the USACE and Central Coast RWQCB in determining if the restoration work, over a 5-year period, results in aquatic functions and services equal to or greater than Pre-Restoration conditions. Results of five annual CRAM studies conclude that the channels appear to be stable and functioning as designed. However, the overall CRAM scores indicate that the stream restoration efforts have provided little overall improvement (Huffman-Broadway Group 2019).

Table 3.10-3 UC Santa Cruz Stormwater Plan Improvement Projects

Improvement Project	Watershed / Tributary	Problem	Project Description
Steinhart Way Diversion (Project: MC-EF-BT-C)	Moore Creek / Baskin Tributary	Runoff from Thimann Lab and Lecture Hall contributes to erosion and overflow of Moore Creek East Fork Baskin Tributary sinkhole.	Divert storm piping from Thimann Lecture and East side of Thimann Labs to new Kerr Hall Detention Basin. Project included installation of new storm drain along Steinhardt Way from Thimann to CFAO detention basin.
Center for Adaptive Optics (CFAO) Outlet Channel to Kerr Hall Detention Basin (Project: MC-EF-BT-SHT-A)	Moore Creek / Science Hill Tributary	Runoff from loading dock creating erosion and poor water quality.	Diversion of Thimann Lab runoff from loading dock to the new Kerr Hall Detention Basin. A new rock-lined channel was created to direct low flows to Kerr Hall Detention Basin; two new culverts; and a series of step pools. The site was revegetated with trees, shrubs, and ground cover.
Kerr Hall Detention Basin (Project: JG-WF-CO-R1-2)	Jordan Gulch / West Fork	Redirect Runoff from Kerr Hall and Thimann to New Detention Basin	Install new detention basin upstream of sinkhole. Redirect runoff from Kerr Hall and Thimann to new detention basin. The project included creating a forebay; creating an impermeable berm at downslope end; and installation of outlet structures. The site was revegetated with trees, shrubs, and ground cover.
Chinquapin Road Channel Improvements (Project JG-EF-J)	Jordan Gulch / East Fork	Runoff from Chinquapin sinkhole overflow and Chinquapin Road contributes to erosion in Jordan Gulch Mainstem	Divert runoff from Chinquapin sinkhole overflow and Chinquapin Road to Upper Quarry sinkholes. This included: providing a culvert dissipation basin at the storm drain outfall from Crown College; installation of infiltration pools adjacent to Chinquapin Road; installation of step pools and channel stabilization at Chinquapin Road and McLaughlin Drive and along McLaughlin Drive leading to the storm drain culvert; re-direction of low flows at 48-inch storm drain into a vegetated channel along the quarry access road; installation of a drainage channel along amphitheater road to sinkhole.
Middle Fork Diversion (Project JG-MF-R1-9)	Jordan Gulch / Middle Fork	Need to route runoff into Upper Quarry sinkhole.	Excavation of swale and raised and widened existing berm to route flows into Upper Quarry sinkhole.
Music Hall Diversion (Projects JG-MS-GMT-A1, JG-MS-GMT-R1-3, MS-GMT-R1-4)	Jordan Gulch / Great Meadow Tributary	Runoff from Arts areas is piped to Jordan Gulch Great Meadow Tributary and contributes to erosion.	Diverted Music detention water to the doline depression including installation of a bioswale to doline depression (400 to 500 LF); installation of a series of step pools; and installation of rock-lined channel from the doline depression to the sinkhole and revegetate. Improvements to stabilize sinkhole include lining of inlet channel with rock and stabilization of sinkhole banks with filter fabric, rock, and=biotechnical measures.

FLOODING

As previously stated, the UC Santa Cruz campus relies on a series of natural drainage courses and sinkholes for storm drainage. Storm water drains via pipes into the natural drainages. Most of the storm water enters the subsurface through a series of sinkholes. Existing campus erosion problems have contributed to build-up of sediment in the sinkholes, which limits their capacity to infiltrate runoff and results in flooding, which is a problem associated with a few sinkholes on the campus. The previous Stormwater Plan identified several critical sinkholes that showed signs of reaching capacity, which could increase the likelihood of spilling to downstream reaches and flooding. The sinkholes that were identified include the Baskin Tributary Sinkhole, the Middle Fork Jordan Gulch Sinkhole, the McLaughlin Drive Sinkhole, and the Kresge Tributary Sinkhole. Three of these sinkholes overflowed during storms in 2004

(Kennedy/Jenks 2004). Several of the completed storm water drainage improvements included in the Infrastructure Improvements Project have diverted runoff from these critical sinkholes to mitigate sedimentation and overflow. Detention basins and settling tanks serve some local building clusters. While this system meets current overall capacity requirements, there are localized areas of concern. Areas that have experienced flooding from surface ponding include the area near the McLaughlin Drive sinkholes and on Moore Creek at Highview Drive south of the main residential campus (UCSC 2006). The UC Santa Cruz campus is not located within a 100-year flood zone; however, as shown in Figure 3.10-3, a small and relatively insignificant area of the Westside Research Park along the southwestern property that slopes towards Antonelli Pond is within a 100-year flood zone (FEMA 2017).

GROUNDWATER RESOURCES/HYDROLOGY

Groundwater

UC Santa Cruz is not within a designated groundwater basin (DWR 2019). It is bordered to the east and immediately to the south by the West Santa Cruz Terrace basin. Areas to the west and immediately north are also not within a designated groundwater basin. The Santa Margarita Basin is situated approximately 2.5 miles north of the main residential campus. The main residential campus can be roughly divided into two hydrogeologic systems, upper/north campus and central/lower campus. These two hydrogeologic systems are directly related to campus geology (i.e., rock types, faults, and fracture zones) (Johnson and Weber & Associates 1989).

<u>Main Residential Campus</u>

North Campus

The north campus hydrogeologic system lies roughly north of McLaughlin Drive and includes shallow water bearing zones of moderate permeability within the Santa Margarita sandstone. Groundwater occurs in portions of thin (5- to 30-foot) eroded remnants of Santa Margarita sandstone. Weathered schist and granitic rocks overlie relatively impermeable unweathered schist and granitic rocks. This area lacks any exposed marble (Johnson and Weber & Associates, 1989). Deeper, fractured bedrock may produce sustainable groundwater, but at low yielding volumes (e.g., 10-30 gpm).

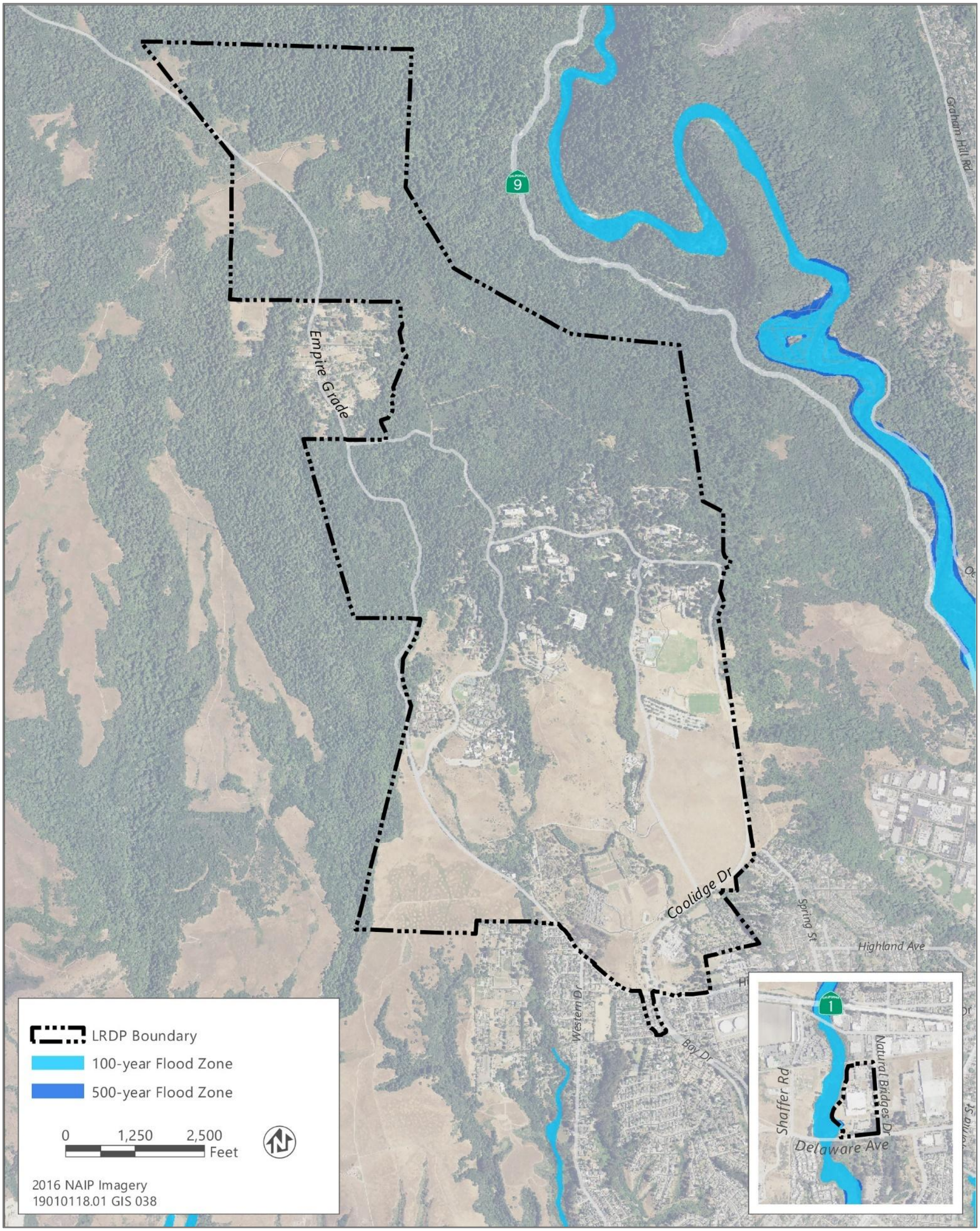
This portion of the main residential campus has a relatively uniform shallow groundwater system; depths to groundwater throughout the main portion of the north campus range from about 2 to 16 feet below ground surface (Nolan, Zinn, and Associates 2004). Due to the shallow groundwater table and the moderate permeability of the near-surface materials, the north campus area has a broad seep zone and several small springs on the slopes leading towards Cave Gulch and lower campus (Johnson and Weber & Associates 1989).

Topographically, the hydrologic system of the upper/north campus is dominated by broad and gently sloping surfaces, giving way to overland flows that seep into the soil and provide groundwater recharge. Surface runoff to the south and west eventually enters the karst (marble) aquifer system of the central and lower campus via Cave Gulch, Moore Creek, and Jordan Gulch. Due to the shallow nature and moderate permeability of the upper/north groundwater system, the aquifer system is not adequate to meet campus water supply needs.

Central/Lower Campus

The lower two-thirds of the main residential campus are largely underlain by marble and schist. The marble allows for the occurrence of karst topography, which is characterized by: (1) a relative absence of surface streams and drainage channels with most precipitation discharging to the subsurface through fractures, and (2) the presence of sinkholes, closed depressions, and swallow holes. More than 50 sinkholes are located throughout the marble-underlain area on the main residential campus and these features are estimated to capture up to 40 percent of campus runoff (Johnson 1988).

Within the marble is an extensive underground drainage network of subterranean caverns and channels formed by the dissolution of marble by groundwater. The locations of these channels are predominantly controlled by north-south and east-west trending bedrock fractures that provide a zone where water can penetrate, weather and dissolve the rock, eventually widening the fracture. Crystalline non-fractured marble will not be readily weathered or dissolved as it exhibits no primary porosity that would allow water penetration in any appreciable amounts. The two main



Source: data downloaded from FEMA in 2020

Figure 3.10-3 Flood Zones

underground karst dissolution channels on the main residential campus lie in Jordan Gulch and Moore Creek, where they coincide with two north-south trending fault/fracture systems, and large volumes of water flows within these channels. Non-fractured areas of the marble bedrock are expected to be non-water bearing. For example, in 1972, a 300-foot-deep boring was drilled within 30 to 50 feet of one of the large north-south fracture zones on campus (i.e., Lower Jordan Gulch) and did not encounter groundwater. By contrast, Test Well #1 was drilled at the intersection of two major fracture zones (400 to 500 feet north of the dry hole) and abundant groundwater was encountered at approximately 100 feet bgs (Johnson and Weber & Associates 1989).

As demonstrated by the aquifer pumping tests described below, a large volume of water is stored in these major underground dissolution channels. There are also several east-west trending fractures in the central and southern portions of the main residential campus (Johnson and Weber & Associates 1989). The distribution of these smaller fractures shows a strong correlation with the location of on-campus sinkholes and off-campus springs. Underground dissolution channels are inferred to be present along the alignments of these fractures. Figure 3.10-4 illustrates the relationship between fractures and sinkholes on the main residential campus and their relationship to off-campus springs. Figure 3.10-5 shows campus well locations and known springs and seeps on and adjacent to the main residential campus.

The karst aquifer system on this portion of the main residential campus has the greatest potential for groundwater extraction and supply on the main residential campus as a substantial portion of (about 40 percent) of precipitation runoff enters the system (Johnson 1988). The groundwater storage capacity within the saturated zone of the karst aquifer is estimated to be at least 3,000 acre-feet, with an equivalent potential storage capacity above the groundwater table (Johnson and Weber & Associates 1989; Gilchrist and Associates 1990). Evaluation of potential sustainable yields from the groundwater table are discussed below under "Aquifer Pumping Tests." However, as UC Santa Cruz receives water from the City for domestic and irrigation purposes, groundwater on the LRDP area is not extracted at this time.

Campus Wells

In the late 1980's a series of exploratory water wells were installed in the on-campus karst aquifer, which underlies the central and lower portion of the main residential campus, in Jordan Gulch. These wells were installed as part of an effort to evaluate groundwater resources on the main residential campus. Changes in well names since installation are summarized below:

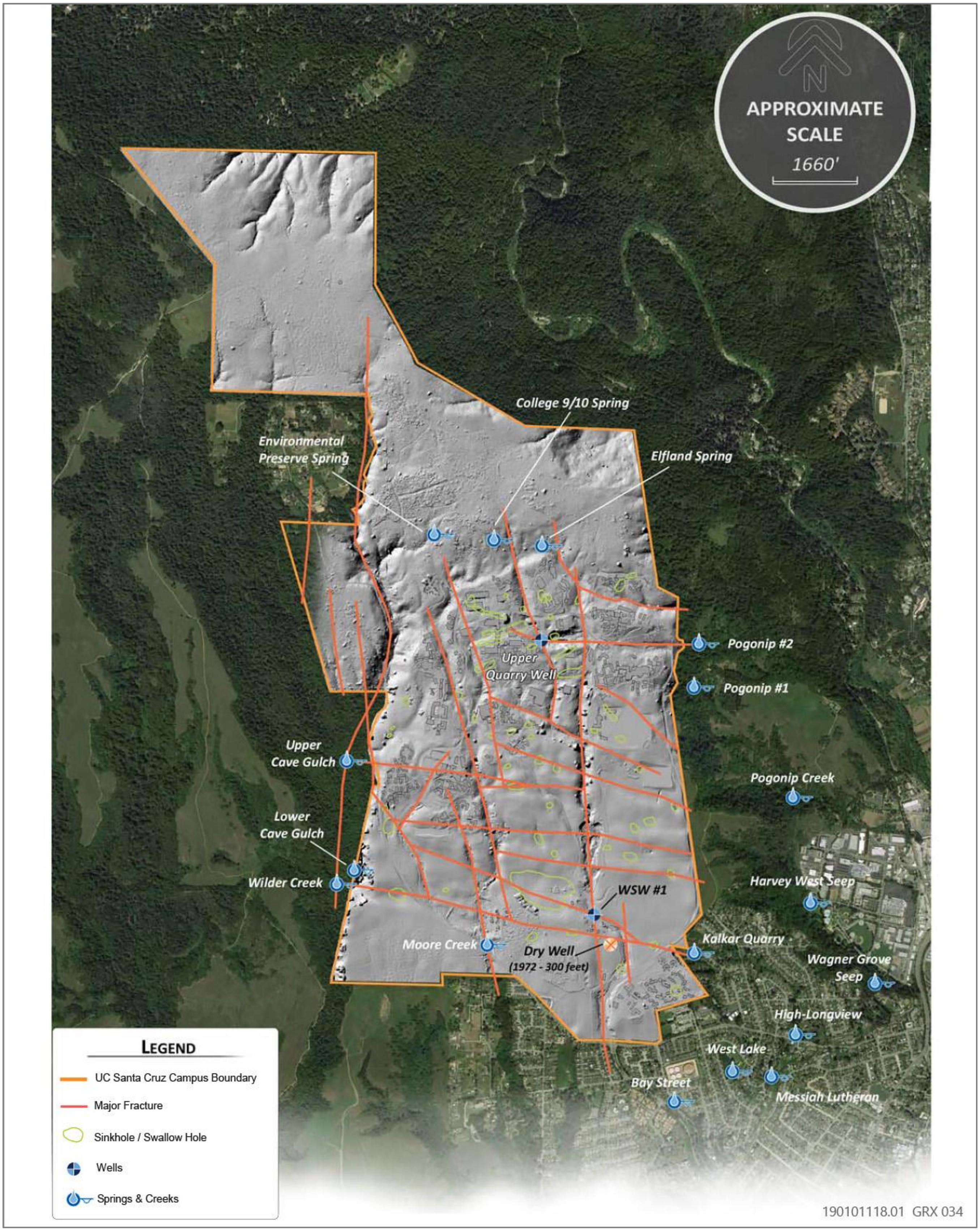
- **Test Well #1** was installed in the lower Jordan Gulch area in December-January, 1987-88, is now designated MW-1A,
- **Test Well #2** was installed in the Upper Quarry area in January 1988, is now designated the Upper Quarry Well,
- **Test Well #3** was installed in lower Jordan Gulch area of in December 1988 is now designated WSW#1, and
- **Test Well #4** was installed in the lower Jordan Gulch area in August 1989, is now designated well MW-1B.

Table 3.10-4 includes a summary of well construction details and Figure 3.10-5 includes the location of the wells.

Well WSW#1 was intended to develop water from the main residential campus karst aquifer at the intersection of a major north-south fracture lineation (Jordan Gulch) and a roughly east-west fracture lineation across the lower campus marked by a line of sinkholes. A detailed evaluation of the karst aquifer, associated spring discharge points, and a history of the well drilling, well completion and initial aquifer testing, including a 7-day aquifer pumping test and recovery test with extensive spring flow monitoring is presented in *Evaluation of the Groundwater Resources at the University of California, Santa Cruz* (Johnson and Weber & Associates 1989).

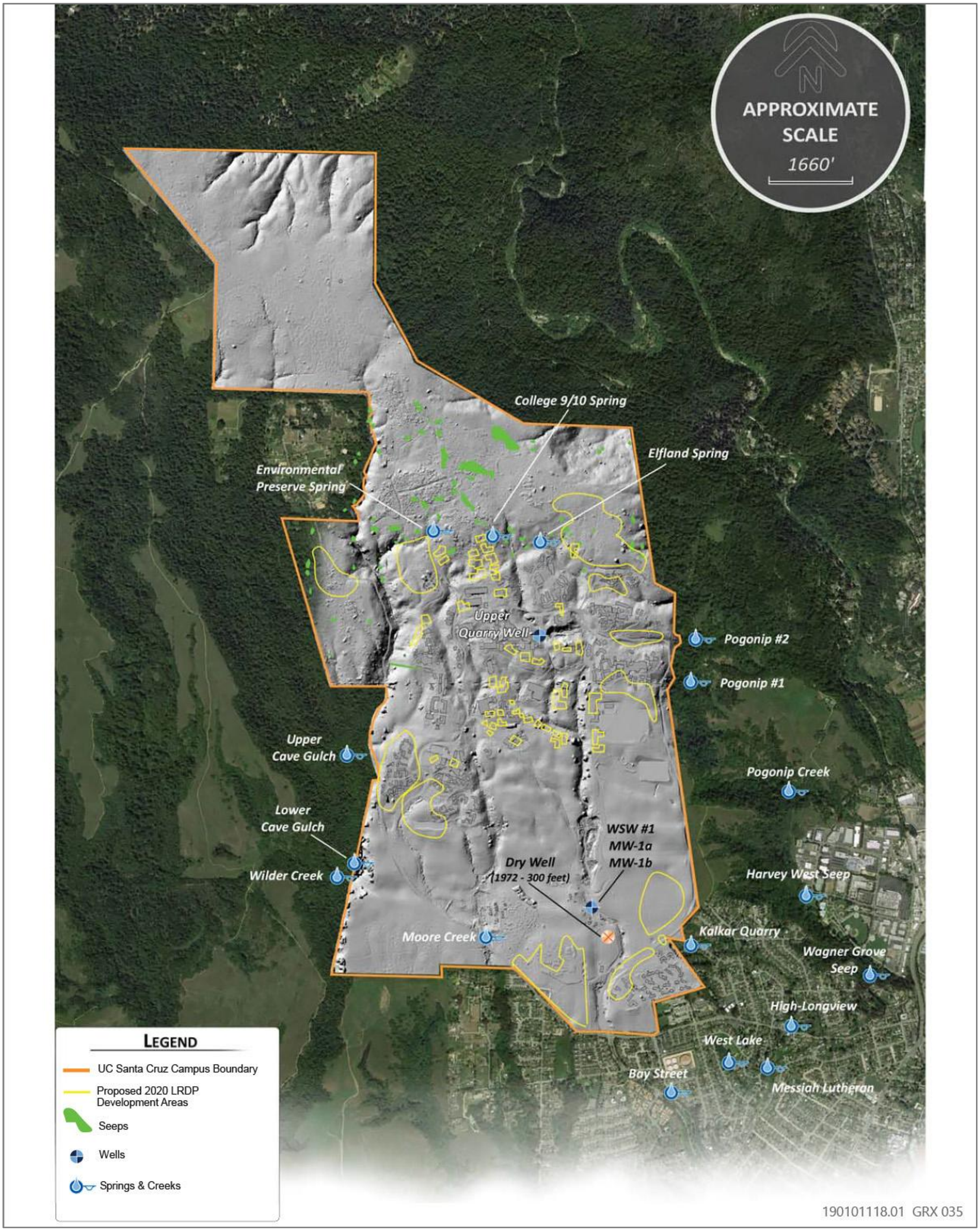
WSW#1 and Monitoring Wells MW-1A and MW-1B

WSW#1 was drilled and completed under City of Santa Cruz permit in December 1988. Drilling to a total depth of 226 feet encountered limestone/marble, with evidence of karst solution channels and zones of hard intact marble interspersed with abundant open to rubble-filled fractures and void spaces. Problems with borehole collapse and loss of circulation were frequent. A completed well was installed to 157 feet, with 5-inch diameter well casing, screened from 77–157 feet deep.



Source: Figure produced and provided by Weber, Hayes & Associates in 2020

Figure 3.10-4 Major Fractures on the UC Santa Cruz Campus



Source: Figure produced and provided by Weber, Hayes & Associates in 2020

Figure 3.10-5 Mapped Springs and Seeps on and Surrounding UC Santa Cruz and On-Campus Wells

Table 3.10-4 Summary of Well Construction Details

Well No.	Date Completed	Total Boring Depth (ft bgs)[1]	Borehole Diameter (in OD)[2]	Conductor Casing Interval (ft bgs)	Type of Conductor Casing	Conductor Casing Diameter (in ID)[3]	Total Well Casing Depth (ft bgs)	Well Casing Diameter (in ID)[3]	Type of Well Casing	Depth of Screened Interval (ft bgs)	Perforation Type	Filter Pack Interval (ft bgs)	Filter Pack Type	Ground Surface Elevation (ft above MSL)[4, 5]	TOC Elevation (ft above MSL)[6]	Static Water Level (ft bgs)[7]	Well Yield (gpm)[8]
MW-1A (Well #1)	1/3/88	297	10.5/7.5	0-27	Steel, 0.156 in	8.5	297	2	PVC, F480/ 200	97-297	Slotted 0.040 in	52-297	5/16-3/8 in gravel	420	424.84	95.60	42.0
MW-1B	8/10/89	186	7.875	None	None	None	160	2	PVC, Sch 40	100-160	Slotted 0.040 in	90-160	8x16 sand	415	418.69	46.79	Not Available
Upper Quarry Well (Well #2)	1/27/88	303	8.5	None	None	None	303	5	PVC, F480	115-303	Slotted 0.040 in	50-115; none at 115-303	3/8 in gravel above packer at 115 ft[9]	714	Not surveyed	94.52	12.5
WSW-1 (Well #3)	12/30/88	226	17.5 / 12.25 / 7.875	1st-0-19, 2nd- 0-108	1st-Steel, 0.188 in; 2nd-PVC F480	1st-12.75 in OD; 2nd- 8.625 in OD	157	5	PVC, F480/ SD R21	77-157 (effectively 108-157)[10]	Slotted 0.040 in	0-157 [11]	8x16 gravel	412	416.41	88.31	92.5

1 bgs = below ground surface.

2 in OD = inches inside diameter; where multiple borehole diameters are listed, the larger are for conductor casing.

3 in ID = inches inside diameter.

4 MSL = Elevation Above Mean Sea Level; ground surface elevations are approximate, top-of-casing elevations are surveyed or calculated.

5 Source: Weber & Associates March 1989, and Gilchrist & Associates, July 1990.

6 TOC = Top of well casing (TOC) survey was conducted by Ifland Engineers at WSW-1, MW-1A and MW-1B on 12/5/07.

7 Source: Weber, Hayes & Associates, November 15, 2019 (MW-1A, MW-1B and WSW#1) and Weber, Hayes & Associates, June 2019 (Upper Quarry Well)

8 gpm = gallons per minute sustained yield during pump test.

9 Borehole sealed by packer at 115 ft bgs, with no filter pack within screened interval below at 115-303 ft bgs.

10 Well diagram and DWR report are unclear or inconsistent about filter pack interval; apparently screened interval is partially within 2nd conductor casing at 77-108 ft bgs, with filter pack extending to surface(?) inside conductor casing. Since the upper screen interval is sealed from the formation from 77-108 ft bgs by the conductor casing, the effective screen interval is therefore 108-157 ft bgs.

Source: Well construction data from Weber & Associates March 1989, and Gilchrist & Associates, July 1990.

Two, 2-inch diameter monitoring wells MW-1A and MW-1B were installed in December/January 1987-88 and August 1989, respectively, in the marble aquifer in Jordan Gulch. Well MW-1A (known in 1988 as Test Well #1) is located approximately 54 feet northeast of well WSW#1. Well MW-1A is completed in the same fracture system as the well WSW#1, as determined by previous dye tracing studies (Aley and Weber & Associates 1994). Well MW-1A also shows pumping influence from pumping in WSW#1 in both the 1989 and 2007 pumping tests (Weber, Hayes and Associates 2007). Monitoring well MW-1B is located approximately 37 feet west of WSW#1, at the western edge of Jordan Gulch. Although this well is completed in fractured marble at a similar ground surface elevation and depth as WSW#1 and MW-1A, it is evidently completed in a separate hydraulic fracture regime, and shows a distinctly higher water level (i.e., 40 to 50 feet higher), and no pumping influence from pumping in WSW#1 in 1989 or 2007.

Upper Quarry Well

The Upper Quarry well (initially designated Test Well #2) was drilled at the intersection of two prominent fracture zones just west of the Upper Quarry. The well was drilled in 1988 to a total depth of 303 feet and screened from 115 to 303 feet. Drilling encountered marble to approximately 200 feet with numerous voids and fractures mainly above the water table. Fractured schist with gneiss and/or granitic dikes was encountered below 200 feet. The cumulative depth of large, open voids including two large caverns was approximately 33 feet (about 11 percent secondary porosity in the marble, likely lower in the fractured schist). The upper 104 feet was cemented to stabilize the hole and provide a surface seal. No long-term pumping test has been conducted to evaluate the yield of this well.

Aquifer Pumping Tests

In 1989, a long-term pumping test on well WSW#1 was conducted at a pumping rate of 100 gallons per minute for 7 days, with extensive spring flow monitoring before, during and after the test. This 1989 test created less than 3 feet of total drawdown in the pumping well and had only 1.38 feet of drawdown in the nearby observation well MW-1A. There was no measurable impact on any spring flow during or after the pumping test. Aquifer analysis indicated the well is completed in a high yielding area of the karst aquifer, with the ability to provide a sustained pumping rate of 100 gpm without dewatering the well, or creating any pumping drawdown at identified spring locations over 2000 feet away (Johnson and Weber & Associates 1989).

In 2007 a 72-hour constant rate well pumping and aquifer recovery test was performed on well WSW#1 to evaluate the sustainable well yield, re-evaluate potential impacts from pumping, and compare the current pumping test results to the previous 7-day pumping and recovery test conducted on this well in 1989. The 72-hour well pumping test was conducted at an average flow rate of 92.5 gpm, followed by a recovery test. Total drawdown in the pumping well during the 3-day test was 0.96 feet. Total drawdown in observation well MW-1A was 0.88 feet. This is an unusually shallow cone of pumping depression, indicating that pumping at this rate did not heavily stress the aquifer. This sustainable flow rate is equivalent to approximately 48.6 MGY or 149 acre-ft/yr.

There was no observed drawdown in observation well MW-1B. Following the pumping test, the pumping well recovered immediately. There was no decrease in flow at several springs monitored during the test that indicated an impact from pumping. These spring locations included Bay Street Spring, Messiah Lutheran Spring, Westlake Pond, and Kalkar Quarry Pond. A previous dye trace study has shown the karst aquifer at WSW#1 to be in direct connection with Bay Street Spring, Messiah Lutheran Spring, and Westlake Pond (Aley and Weber & Associates 1994).

An expanded Initial Study of the Farm [i.e., Center for Agroecology and Sustainable Food Systems (CASFS)] and Arboretum Irrigation well (Well #3, aka WSW#1) was prepared in 1990 that addressed the potential environmental impacts from use of this well to irrigate cultivated lands at the CASFS and Arboretum (Gilchrist and Associates 1990). This report included an evaluation of well WSW#1 7-day pumping test along with a 5-year record of spring flow data and concluded that it was unlikely that pumping from this well at 100 gpm would have any effect on the springs surrounding UC Santa Cruz. Even with greater pumping rates, this study concluded it is probable that any dewatering of the marble aquifer would be rapidly recharged by captured runoff and subsurface flow carried in the karst solution channels during winter storms. However, the report recommended that due to the complexity of the karst fracture system, use of WSW#1 should incorporate long-term monitoring of springs near the main residential campus, as flow patterns and groundwater movement in the karst aquifer are not completely understood.

Well WSW#1 has not been used for water supply since it was installed in 1989, although annual water quality samples and water level measurements have been collected.

Dye Trace Studies

Four dye tracing studies have been completed on the main residential campus that provide information on groundwater in the karst area of the main residential campus. The first study was conducted in 1994 to evaluate groundwater flow paths and to determine whether pumping from well WSW #1, located in the Jordan Gulch watershed in the lower campus, would affect flow rates in individual springs in the area on and off campus. Dye was injected into monitoring well MW-1A (situated approximately 50 feet northeast of WSW#1) and into a sinkhole located near the East Remote parking lot (Aley and Weber & Associates 1994). Results of this study confirmed that dye traveled fairly rapidly between the dye injection location and nearby monitoring wells and springs. The dye was detected at four of the monitoring locations within 2 days and at eight of the monitoring locations within 2 weeks. The monitoring data also demonstrated that WSW #1 is hydraulically connected (i.e., partial or complete groundwater flow path between locations) to MW-1a, MW-1b, Bay Street Spring, West Lake Spring, and Messiah Lutheran Spring (Aley and Weber & Associates 1994). The study concluded that WSW#1 is hydraulically connected to major portions of the karst aquifer and therefore, if pumped, is unlikely to substantially affect the discharge of any individual spring or springs.

Three subsequent dye tracing studies were conducted on the central campus to evaluate the potential for building foundation pressure grouting programs to impact groundwater quality or flow rates at springs around the main residential campus. For each of these studies dye injected at the proposed grouting locations on the central campus was not detected at any of the off-campus monitoring points within each of the 18-week study periods, indicating that there are no rapid flow paths capable of moving water, grout or other fluid from the dye injection sites to off-campus springs. Because no rapid flow paths were identified, the studies concluded that pressure grouting programs in the areas tested would not have any significant impact on water recharge in the karst aquifer, or on water discharge rates or quality at springs, through leaching or grout transport (Weber, Hayes & Associates 2000, 2001a, 2001b).

GROUNDWATER RESOURCES OF THE REGION SURROUNDING THE MAIN RESIDENTIAL CAMPUS

The Purisima formation, Santa Margarita sandstone, and weathered granitic rocks are the main water bearing formations in the area surrounding the main residential campus. The Purisima formation underlies the eastern portions of the City of Santa Cruz and the adjacent communities of Soquel and Live Oak and is the primary source of groundwater in the Santa Cruz area. The City extracts groundwater from a network of wells installed in the Purisima formation, which accounts for approximately 5 percent of the City's water supply. Other water districts such as the Soquel Creek Water District and private wells also draw water from this formation (UCSC 2006).

In the area northwest of the main residential campus along Ben Lomond Mountain, private wells are installed in fractured and weathered granitic rock. These wells typically have low yields of 5 to 20 gpm, which are adequate for single households but not for larger developments (Johnson 1985).

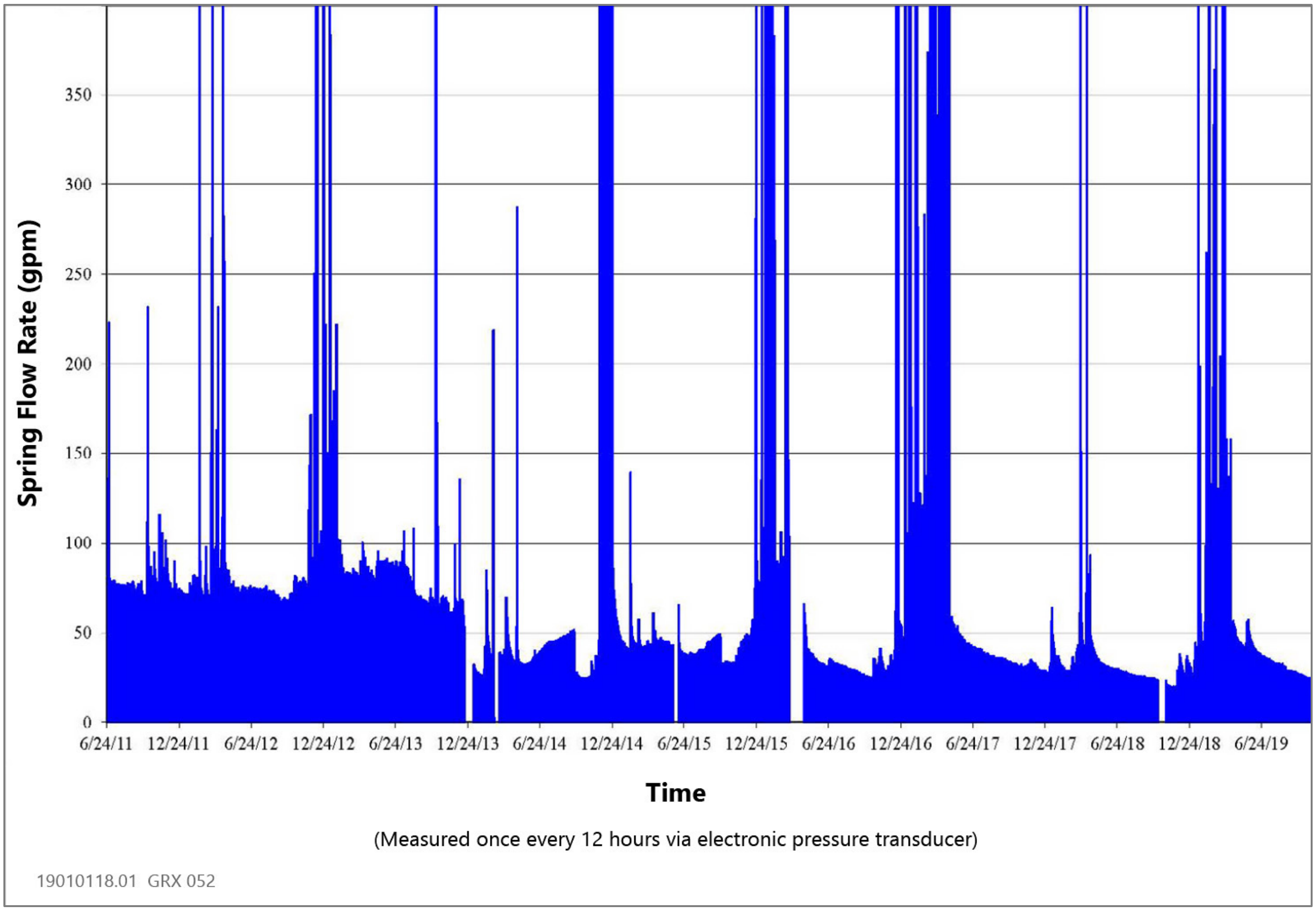
Karst groundwater from fractures and solution cavities within the marble formation fed by captured surface runoff and groundwater flow from the north campus discharges to surface water in the surrounding areas via numerous springs and seeps which feed the drainages in the San Lorenzo River watershed to the north and east of the main residential campus; the Cave Gulch and Wilder Creek watersheds to the west of the main residential campus; and the Moore Creek, Arroyo Seco, and Jordan Gulch/Neary Lagoon watersheds south to southwest of the main residential campus (UCSC 2006). It is also likely that some of the groundwater originating on campus reaches the San Lorenzo River and the Pacific Ocean as subsurface flow (Johnson and Weber & Associates 1989).

The springs and seeps that originate from the upper campus seep zone and feed the San Lorenzo River Watershed north and northeast of the upper campus include Tunnel Gulch Tributaries along the north campus boundary and Highway 9 Horse Trough Spring located along State Highway 9 above the San Lorenzo River immediately east of upper campus. The karst springs and seeps that emerge east of the main residential campus boundary and flow toward the San Lorenzo River include Pogonip Springs #1 and #2, the Pogonip Creek Spring, Harvey West Seep, and Wagner Grove Seep. Southeast of the main residential campus boundary the karst springs that flow toward Neary Lagoon include Kalkar Quarry Spring, Messiah Lutheran Church Spring, High Street Spring, West Lake Spring, and Bay Street Spring. South of the main residential campus, the karst zone Arboretum and Moore Creek seeps feed Moore Creek, which flows to Antonelli Pond and the coastal plain. Along the western campus boundary, the Wilder Creek and Cave Gulch watersheds are fed by the Wilder Creek and Cave Gulch source seeps from the upper/north campus sandstone/schist seep zone, and the Upper and Lower Cave Gulch Springs, and Wilder Creek Spring from the karst aquifer (Johnson and Weber & Associates 1989).

UC SANTA CRUZ HYDROLOGIC MONITORING

Spring and Stream Flow Monitoring

Thirteen recognized springs, seeps or spring fed streams that are linked to the karst aquifer have been mapped to outcrop on- and off-campus. Monthly to semi-annual monitoring of flows from these surface water locations has been conducted by UC Santa Cruz since 1984; currently, nine are being monitored for flow monthly. In 2011, UC Santa Cruz obtained permission from the City of Santa Cruz Water Department (Water Department) to access and retrofit an existing weir that has been used by the Water Department to measure Bay Street Spring flow rates since 1980. The weir is housed inside a manhole on Water Department property just east of Bay Street, adjacent to, and upstream of the Bay Street Spring monitoring station that had been monitored since 1984. The weir was retrofitted with a stilling well and an electronic pressure transducer was installed and secured to the inside of the stilling well. The transducer is calibrated to record the height of water flowing over the 90 degree V-notch weir once every 12 hours in order to obtain high resolution spring flow monitoring data. A histogram of the continuous monitoring data that has been collected since June 2011 is shown on Figure 3.10-6. The high-resolution spring flow data confirms an almost immediate response to individual precipitation events and a strong seasonal trend of increased flow through the wet season, followed by a slow and steady period of reduced flow through the rest of the year during the drier months to base flow levels. Base flows are generally higher during wetter years and lower during the drier years. Construction related to the Bay Street Reservoir Replacement Project in 2013 (located ~500 feet north of the weir manhole) periodically and briefly affected observed spring flow at the weir manhole location due to brief diversions of the sub-drain system that delivers the spring water to this location. Following a mid-December 2013 diversion of the sub-drain system that was conducted in connection with the Bay Street Reservoir Replacement Project flows at the weir manhole dropped by more than half of the historic base flow rate (i.e., from about 65 gpm to less than 30 gpm). This is observed on Figure 3.10-6. It is suspected that when the sub-drain was plugged for downstream retrofitting the backpressure likely ruptured the historic piping resulting in upstream flow loss to the subsurface. All data collected following this incident appears to be erroneous with respect to the long-term record; however, strong seasonal trends are still observed.



Source: Data provided by 2NDNATURE in 2021.

Figure 3.10-6 Bay Street Spring Flow Data

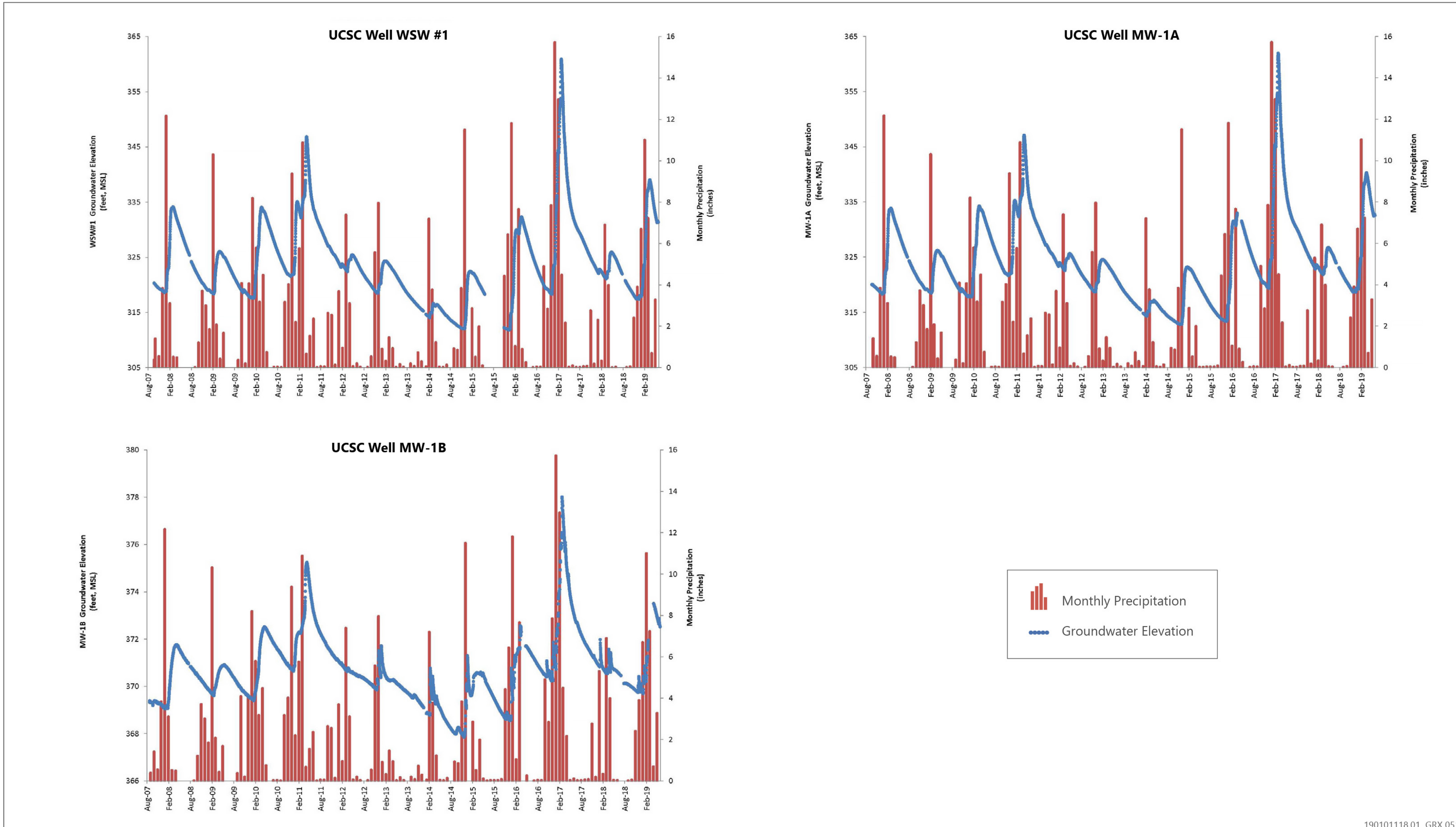
In addition, groundwater levels are measured in three wells that are completed in the karst aquifer in lower Jordan Gulch. The monitoring locations are shown on Figure 3.10-5. Because wet season measurements are influenced by the amount and timing of rainfall, there is more variation in wet season measurements. The dry season measurements represent base flow conditions and are therefore more suitable for year-to-year comparisons. The monitoring has indicated that development activities on campus have not created a measurable increase or decrease in flow rates at any of the springs and streams monitored, and have not affected groundwater elevations in on–campus monitoring wells (Weber, Hayes and Associates 2019a). A statistical summary of the monitoring data gathered by UC Santa Cruz since 1984 that is grouped by water year type, including average, maximum, minimum spring flows and standard deviation for spring or spring fed stream discharge data, and water surface elevations for the monitoring wells is presented in Table 3.10-5. Table G1-1 in Appendix G presents a summary of all monitoring data since 1984.

Continuous Water Level Monitoring

In August 2007, UC Santa Cruz installed dedicated electronic pressure transducers in wells WSW#1, MW-1A, and MW-1B, see Figure 3.10-5). The transducers are programmed to record water level data once every 12 hours to obtain high-resolution data of seasonal water level fluctuations in these wells. These transducers continue to record water levels to date. Hydrographs of water level fluctuations from wells WSW#1, MW-1A, and MW-1B along with superimposed monthly precipitation data are shown on Figure 3.10-7. The high-resolution data set confirms a strong seasonal trend of rapid groundwater recharge and water level rise after the start of winter rainfall followed by a slow and steady period of groundwater decline through the rest of the year during the drier months. Water levels in wells WSW#1 and MW-1A fluctuate in tandem, with nearly identical response to aquifer recharge and drainage. Seasonal water level rise observed in these wells since 2007 has ranged from approximately 43 feet during the wettest period monitored (i.e., ~36.5 inches of precipitation between December and March of the 2016-2017 water year) to approximately 2.5 feet during the 2013-2014 water year when only approximately 14 inches of precipitation was recorded for the entire water year. Data collected from well MW-1B indicates a similar recharge pattern as that observed in nearby wells WSW#1 and MW-1A, yet on a much smaller scale and with a time lag (i.e., observed to be on the order of a few days to several weeks). As noted in the Campus Wells Section, MW-1B is evidently completed in a separate hydraulic fracture regime, and shows a distinctly higher water level (i.e., 40 to 50 feet higher), and no pumping influence from pumping in WSW#1 in 1989 or 2007. Groundwater elevations are generally higher during wetter years and lower during the drier years. Most notably, during both wetter and drier years, dry season base water levels observed for wells WSW#1 and MW-1A have only varied by approximately 10 feet, with the base level following the driest years ever recorded in California state history being the lowest observed for the continuous water level monitoring data set. This relatively small fluctuation in base water levels from wetter years to several consecutive years of drought suggests a significant aquifer storage capacity in this area of the karst.

Surface Water and Groundwater Quality

Historically, UC Santa Cruz monitored water quality at nine spring, groundwater and/or surface locations on the main residential campus. Samples were collected to test the water quality of groundwater, spring water, and surface water. Samples collected at these locations were tested for general mineral, physical, and inorganic content and semi- to non-volatile range hydrocarbons (diesel-kerosene-motor oil range) and compared against performance criteria (e.g., water quality standards, guidelines, and benchmarks). This historic monitoring program was conducted between 1989 through 2008 pursuant to the 1988 LRDP Mitigation Measure 4.1-9. In 2009, UC Santa Cruz began monitoring storm water discharge from specific land use areas around campus as part of the University's Storm Water Management Program. Currently, samples are collected from seven surface locations and two wells (WSW#1 and Upper Quarry Well) during the first significant precipitation event of the wet season and are tested for general indicator storm water parameters, including pH, total suspended solids, specific conductance, and oil & grease. In addition, three of the surface water locations are tested for general mineral, physical, and inorganic content. An analysis of historic and recent sampling does not show an increase in urban runoff pollutants over time and there does not appear to be any significant identifiable water quality impacts from campus activities (Weber, Hayes and Associates 2019b).



Source: Data provided by 2NDNATURE in 2021.

Figure 3.10-7 Temporal Water Level Fluctuation and Monthly Precipitation Data for On-Campus Wells

Table 3.10-5 Statistical Summary of Spring and Stream Flow Rates and Groundwater Elevation

Location	Bay Street Spring	West Lake Outlet	Messiah Lutheran Spring	Kalkar Spring Quarry	High-Longview Spring	Wagner Grove Seep	Harvey West Seep	Pogonip Creek System	Pogonip Spring #1	Pogonip Spring #2	Upper Cave Gulch	Lower Cave Gulch	Wilder Creek Spring	Moore Creek Spring		MW-1A	MW-1B	WSW 1
Surface Elevation	235 ft MSL	255 ft MSL	255 ft MSL	310 ft MSL	250 ft MSL	200 ft MSL	110 ft MSL	150 ft MSL	435 ft MSL	500 ft MSL	540 ft MSL	330 ft MSL	330 ft MSL	410 ft MSL		424.84 (TOC, ft MSL)	418.69 (TOC, ft MSL)	416.41 (TOC, ft MSL)

Statistical Summary (Per Monitoring Event in Very Dry Years, < 23.5 in/yr precipitation)

Location	Bay Street Spring	West Lake Outlet	Messiah Lutheran Spring	Kalkar Spring Quarry	High-Longview Spring	Wagner Grove Seep	Harvey West Seep	Pogonip Creek System	Pogonip Spring #1	Pogonip Spring #2	Upper Cave Gulch	Lower Cave Gulch	Wilder Creek Spring	Moore Creek Spring		MW-1A	MW-1B	WSW 1
Flow Rate	gpm														Total Q gpm	Ave. ft MSL	Ave. ft MSL	Ave. ft MSL
Average	116.1	25.3	40.9	52.0	1.3	0	0.7	196.4	47.7	10.2	0	10.6	214.6	1.3	716.9	315.6	368.3	314.2
Std Dev (average only)	33.6	27.4	14.5	49.5	0.6	0	0.5	105.7	52.9	8.7	0	8.0	176.4	0.8	NA	5.6	1.1	2.0
Maximum	147.1	95.7	58.7	158.0	1.9	0	1.0	398.7	152.0	22.1	0	21.9	500.0	2.0	NA	327.0	370.4	316.2
Minimum	21.0	0.0	3.6	0.0	0.8	0	0.0	113.1	10.0	2.2	0	5.0	28.7	0	NA	310.5	367.3	312.1
Dry Season Average (June-Sept.)	104.3	8.8	31.0	26.8	0.8	0	0.5	162.1	17.8	3.1	0	5.0	102.0	1.0	463.1	313.5	367.8	312.1
Annual Flow	acre-feet/year														Total Q acre-feet/year	NA	NA	NA
Average	187.2	40.7	65.9	83.9	2.1	0	1.1	316.8	76.9	16.4	0	17.2	346.1	2.0	1156.4	NA	NA	NA
Surface Elevation	235 ft MSL	255 ft MSL	255 ft MSL	310 ft MSL	250 ft MSL	200 ft MSL	110 ft MSL	150 ft MSL	435 ft MSL	500 ft MSL	540 ft MSL	330 ft MSL	330 ft MSL	410 ft MSL		424.84 (TOC, ft MSL)	418.69 (TOC, ft MSL)	416.41 (TOC, ft MSL)

Statistical Summary (Per Monitoring Event in Dry Years, 23.5 - 33.2 in/yr precipitation)

Location	Bay Street Spring	West Lake Outlet	Messiah Lutheran Spring	Kalkar Spring Quarry	High-Longview Spring	Wagner Grove Seep	Harvey West Seep	Pogonip Creek System	Pogonip Spring #1	Pogonip Spring #2	Upper Cave Gulch	Lower Cave Gulch	Wilder Creek Spring	Moore Creek Spring		MW-1A	MW-1B	WSW 1
Flow Rate	gpm														Total Q gpm	Ave. ft MSL	Ave. ft MSL	Ave. ft MSL
Average	117.4	39.6	48.1	80.2	27.0	0	3.4	191.0	24.7	7.8	9.1	6.9	274.5	3.6	833.3	315.6	366.3	324.3
Std Dev (average only)	32.3	39.3	17.2	58.5	18.0	0	5.3	46.3	40.0	8.6	8.5	3.1	417.3	7.7	NA	4.8	8.8	9.0
Maximum	180.0	175.9	108.2	245.8	70.4	0	18.8	390.7	201.0	40.0	23.5	12.6	2617.0	25.0	NA	323.2	370.4	369.1
Minimum	23.0	0.0	12.0	0.0	0.0	0	0.8	114.5	2.8	1.2	1.0	1.9	7.7	0.0	NA	308.1	321.1	313.0

Location	Bay Street Spring	West Lake Outlet	Messiah Lutheran Spring	Kalkar Spring Quarry	High-Longview Spring	Wagner Grove Seep	Harvey West Seep	Pogonip Creek System	Pogonip Spring #1	Pogonip Spring #2	Upper Cave Gulch	Lower Cave Gulch	Wilder Creek Spring	Moore Creek Spring		MW-1A	MW-1B	WSW 1
Dry Season Average (June-Sept.)	95.3	7.1	34.5	50.2	11.6	0	0.9	184.5	15.3	6.1	2.6	5.9	93.7	0.2	508.0	315.3	368.3	322.7
Annual Flow	acre-feet/year														Total Q acre-feet/year	NA	NA	NA
Average	189.31	63.87	77.61	129.44	43.54	0	5.49	308.05	39.91	12.64	14.65	11.18	442.73	5.74	1344.15	NA	NA	NA
Surface Elevation	235 ft MSL	255 ft MSL	255 ft MSL	310 ft MSL	250 ft MSL	200 ft MSL	110 ft MSL	150 ft MSL	435 ft MSL	500 ft MSL	540 ft MSL	330 ft MSL	330 ft MSL	410 ft MSL		424.84 (TOC, ft MSL)	418.69 (TOC, ft MSL)	416.41 (TOC, ft MSL)

Statistical Summary (Per Monitoring Event in Normal Years, 33.2 - 51.1 in/yr precipitation)

Location	Bay Street Spring	West Lake Outlet	Messiah Lutheran Spring	Kalkar Spring Quarry	High-Longview Spring	Wagner Grove Seep	Harvey West Seep	Pogonip Creek System	Pogonip Spring #1	Pogonip Spring #2	Upper Cave Gulch	Lower Cave Gulch	Wilder Creek Spring	Moore Creek Spring		MW-1A	MW-1B	WSW 1
Flow Rate	gpm														Total Q gpm	Ave. ft MSL	Ave. ft MSL	Ave. ft MSL
Average	112.0	76.0	48.5	170.7	20.0	11.6	11.4	212.9	37.4	8.1	9.9	34.0	438.5	2.7	1,193.6	321.7	367.6	328.0
Std Dev (average only)	33.8	80.0	26.1	192.2	34.0	57.3	30.1	93.3	58.3	10.0	24.7	53.9	582.8	1.9	NA	7.4	5.7	7.0
Maximum	192.3	309.5	155.6	1110.6	116.0	298.3	157.9	559.5	329.0	48.7	117.9	175.0	3040.6	7.5	NA	340.5	372.7	339.0
Minimum	36.0	0.0	7.8	0.0	0.0	0.0	0.8	92.1	2.9	1.2	0.0	2.6	21.3	0.0	NA	310.7	336.8	311.8
Dry Season Average (June-Sept.)	88.0	21.9	38.1	120.9	0.0	0.0	3.1	189.4	20.4	4.3	0.9	13.5	186.0	1.5	687.9	320.8	368.9	328.3
Annual Flow	acre-feet/year														Total Q acre-feet/year	NA	NA	NA
Average	180.7	122.6	78.2	275.4	32.2	18.7	18.4	343.4	60.4	13.1	16.0	54.8	707.3	4.3	1925.3	NA	NA	NA
Surface Elevation	235 ft MSL	255 ft MSL	255 ft MSL	310 ft MSL	250 ft MSL	200 ft MSL	110 ft MSL	150 ft MSL	435 ft MSL	500 ft MSL	540 ft MSL	330 ft MSL	330 ft MSL	410 ft MSL		424.84 (TOC, ft MSL)	418.69 (TOC, ft MSL)	416.41 (TOC, ft MSL)

Statistical Summary (Per Monitoring Event in Wet Years, 51.1 - 71.0 in/yr precipitation)

Location	Bay Street Spring	West Lake Outlet	Messiah Lutheran Spring	Kalkar Spring Quarry	High-Longview Spring	Wagner Grove Seep	Harvey West Seep	Pogonip Creek System	Pogonip Spring #1	Pogonip Spring #2	Upper Cave Gulch	Lower Cave Gulch	Wilder Creek Spring	Moore Creek Spring		MW-1A	MW-1B	WSW 1
Flow Rate	gpm														Total Q gpm	Ave. ft MSL	Ave. ft MSL	Ave. ft MSL

Location	Bay Street Spring	West Lake Outlet	Messiah Lutheran Spring	Kalkar Spring Quarry	High-Longview Spring	Wagner Grove Seep	Harvey West Seep	Pogonip Creek System	Pogonip Spring #1	Pogonip Spring #2	Upper Cave Gulch	Lower Cave Gulch	Wilder Creek Spring	Moore Creek Spring		MW-1A	MW-1B	WSW 1
Average	131.4	190.0	71.8	440.0	--	12.1	40.0	288.4	72.1	25.6	173.3	225.1	1054.8	8.5	2733.1	328.9	371.4	329.3
Std Dev (average only)	47.7	128.0	29.4	294.5	--	34.6	68.6	133.5	61.9	19.4	361.8	388.5	1266.6	6.8	NA	6.6	1.3	8.5
Maximum	230.9	406.8	135.4	971.5	--	115.7	181.6	574.7	233.5	64.6	1239.9	1357.5	4944.0	20.0	NA	340.0	373.1	344.6
Minimum	70.0	16.7	30.0	123.4	--	0.0	1.0	80.3	11.6	5.5	0.0	3.4	132.3	0.5	NA	319.9	369.5	316.4
Dry Season Average (June-Sept.)	94.3	59.8	52.5	159.0	--	0.0	1.5	303.3	38.8	9.9	0.0	27.0	212.8	1.2	960.1	327.2	371.1	327.3
Annual Flow	acre-feet/year														Total Q acre-feet/ year	NA	NA	NA
Average	212.0	306.5	115.7	709.7	--	19.6	64.5	465.2	116.2	41.3	279.5	363.0	1701.5	13.7	4408.5	NA	NA	NA
Surface Elevation	235 ft MSL	255 ft MSL	255 ft MSL	310 ft MSL	250 ft MSL	200 ft MSL	110 ft MSL	150 ft MSL	435 ft MSL	500 ft MSL	540 ft MSL	330 ft MSL	330 ft MSL	410 ft MSL		424.84 (TOC, ft MSL)	418.69 (TOC, ft MSL)	416.41 (TOC, ft MSL)

Statistical Summary (Per Monitoring Event in Very Wet Years, > 71.0 in/yr precipitation)

Location	Bay Street Spring	West Lake Outlet	Messiah Lutheran Spring	Kalkar Spring Quarry	High-Longview Spring	Wagner Grove Seep	Harvey West Seep	Pogonip Creek System	Pogonip Spring #1	Pogonip Spring #2	Upper Cave Gulch	Lower Cave Gulch	Wilder Creek Spring	Moore Creek Spring		MW-1A	MW-1B	WSW 1
Flow Rate	gpm														Total Q gpm	Ave. ft MSL	Ave. ft MSL	Ave. ft MSL
Average	84.2	197.3	105.2	875.8	--	3.9	9.4	365.3	271.3	30.1	189.6	126.8	992.4	10.6	3262.0		338.3	
Std Dev (average only)	29.5	181.4	78.3	762.7	--	3.9	4.4	187.3	290.1	24.7	189.6	121.0	785.6	11.1	NA		13.0	#DIV/0!
Maximum	116.0	451.1	236.6	1865.5	--	7.8	13.8	646.9	761.5	59.0	379.3	247.8	1991.6	29.2	NA		356.2	
Minimum	36.0	23.1	30.0	111.8	--	0.0	5.0	155.6	24.0	1.2	0.0	5.9	156.7	0.0	NA		324.1	
Dry Season Average (June-Sept.)	36.0	27.7	81.0	155.4	--	0.0	0.0	244.3	203.0	10.6	0.0	0.0	294.8	0.0	1052.8		327.8	326.6
Annual Flow	acre-feet/year														Total Q acre-feet/ year	NA	NA	NA
Average	135.9	318.2	169.8	1412.7	--	6.3	15.2	589.2	437.6	48.6	305.9	204.6	1600.8	17.0	5261.6	10523.3	NA	

Notes: gpm = gallons per minute, ft MSL = Feet above Mean Sea Level, TOC = Top of Casing elevation, NA = Not Applicable, Q = Discharge Flow

Source: UC Santa Cruz 2020.

3.10.3 Environmental Impacts and Mitigation Measures

SIGNIFICANCE CRITERIA

- violate any water quality standards or waste discharge requirements or otherwise substantially degrade surface or ground water quality;
- substantially decrease groundwater supplies or interfere substantially with groundwater recharge such that the project may impede sustainable groundwater management of the basin;
- substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river or through the addition of impervious surfaces, in a manner which would:
  - result in substantial erosion or siltation on- site or off-site;
  - substantially increase the rate or amount of surface runoff in a manner that would result in flooding on-site or off-site;
  - create or contribute runoff water that would exceed the capacity of existing or planned stormwater- drainage systems or provide substantial additional sources of polluted runoff;
  - impede or redirect flood flows
- in flood hazard, tsunami, or seiche zones, risk release of pollutants due to project inundation; and/or
- conflict with or obstruct implementation of a water quality control plan or sustainable groundwater management plan.

ANALYSIS METHODOLOGY

Evaluation of potential hydrologic and water quality impacts is based on a review of existing documents and studies that address water resources in the vicinity of the LRDP area. Information obtained from these sources was reviewed and summarized to describe existing conditions and to identify potential environmental effects, based on the standards of significance presented in this section. In determining the level of significance, the analysis assumes that implementation of the 2021 LRDP would comply with relevant federal, state, and local laws, ordinances, and regulations.

Surface Water

As noted above, the assessment of impacts to surface waters is based on a review of existing documents and studies related to surface water within the LRDP area and in the region. To ensure compliance with relevant federal, state, and local laws, ordinances, and regulations, UC Santa Cruz requires individual campus developments to comply with the Post Construction Stormwater Management Requirements (UC Santa Cruz Post-Construction Requirements) to provide water quality, runoff reduction, and peak management of stormwater equal to the volume of runoff generated by the 85th or 95th percentile 24-hour storm event, based on local rainfall data. In addition, UC Santa Cruz is evaluating options for providing a more comprehensive, integrated, and consistent approach to maintain the health and functionality of the existing campus storm drain system, natural drainages and karst system, as well as proposed improvements to those systems, and for the development of non-potable water supplies. These options would consider development envisioned under the 2021 LRDP, current water infrastructure planning, campus projects currently under development, and UC Santa Cruz's goals and aspirations for watershed health, water sustainability, and resilience to possibly provide solutions on a more district or area scale, instead of by individuals building.

Groundwater

Impacts from potential groundwater extraction were evaluated by examining previous hydrogeologic studies including aquifer pumping and recovery tests conducted on campus well WSW#1. To analyze potential effects of groundwater extraction from the karst aquifer, a water balance for the karst aquifer was estimated. The water balance is a quantitative evaluation of groundwater recharge and is explained in terms of inputs (precipitation infiltration) and outputs (evapotranspiration, precipitation runoff, groundwater discharge via springs and groundwater underflow out of the area, and groundwater extraction via well pumping). For this analysis, hydrologic runoff modeling was completed for each of the main residential campus watersheds under existing land use conditions using the stormwater tool to estimate load reductions (TELR) (Beck et al. 2017) to generate annual percent runoff estimates that are used in the water balance calculations. A description of the modeling methodology, calculations and results are included in a technical memorandum prepared by 2NDNATURE, which is included as Appendix G.

ISSUES NOT EVALUATED FURTHER

Inundation by Tsunami, Seiche, or Mudflow

Tsunamis are large waves created by earthquakes, undersea landslides, or volcanic eruptions. Low-lying coastal areas such as tidal flats, marshes, and former bay margins that have been artificially filled are susceptible to inundation. The California Department of Conservation prepares tsunami inundation maps for coastal areas and all populated areas at risk to tsunami within the state based on the maximum tsunami threat for that area. Based on the tsunami inundation map prepared for Santa Cruz County (July 2009) there are few low-lying coastal areas of Santa Cruz County that are at risk from tsunami, which includes the low-lying area of Natural Bridges Sate Beach that continues inland to Antonelli Pond, which is immediately west of the Westside Research Park. However, the Westside Research Park itself and the camps is not mapped as being at risk; therefore, this issue is not evaluated further. Additionally, because the LRPD area is distant from any large, enclosed water bodies that could create seiche waves and located in relatively gently sloping topography or in areas dominantly comprised of hard, stable granitic and metamorphic rocks which underlie much of UC Santa Cruz where the risk of mudflow is minimal, these issues are also dismissed from further evaluation.

IMPACTS AND MITIGATION MEASURES

Impact 3.10-1: Violate Any Waste Discharge Requirements That Would Substantially Degrade Surface or Groundwater Quality

UC Santa Cruz does not discharge wastewater directly to any receiving water bodies; therefore, its wastewater is not subject to wastewater discharge requirements. Wastewater generated on the main residential campus and Westside Research Park is discharged to the City of Santa Cruz sewer system and is treated at the City's wastewater treatment plant. Therefore, implementation of the 2021 LRDP would result in a **less-than-significant** impact.

UC Santa Cruz, including the Westside Research Park, does not discharge wastewater directly to any receiving water bodies; therefore, its wastewater is not subject to wastewater discharge requirements. Wastewater generated on the main residential campus and Westside Research Park is discharged to the City of Santa Cruz sewer system and is treated at the City's wastewater treatment plant. Development under the 2021 LRDP would increase the volume of wastewater generated on campus by increasing both the UC Santa Cruz population and the number of campus buildings and facilities. As part of ongoing sustainability efforts, UC Santa Cruz evaluates the potential for on-site water recycling on a project-by-project basis, as demonstrated by the on-site water recycling system included as part of Student Housing West, which is a planned-but-not operational project (see Chapter 5, "Cumulative Impacts.") As part of Student Housing West, wastewater generated in new on-campus housing at both the Heller and Hagar sites will be collected and treated in wastewater treatment facilities that would be located within each respective site. The facilities would include a membrane bioreactor (MBR) plant to treat the wastewater and generate recycled water for irrigation and toilet flushing use. However, no campus-wide plan for water recycling is proposed. In general, the types of activities and uses in the LRDP area would remain largely unchanged, and therefore the quality of wastewater that is discharged to the sanitary sewer system would remain unchanged. The use of hazardous materials on campus is projected to increase under the 2021 LRDP because of increase laboratory space and campus populations. However, the types of chemicals and biological agents used in the future would likely be similar to those used in existing laboratories on campus. As discussed in Section 3.9, “Hazards and Hazardous Materials,” the UC Santa Cruz Environmental Health and Safety division implements comprehensive programs to handle hazardous waste. All new laboratories in the LRDP area would be required to comply with campus safety programs that regulate the handling, storage, and disposal of hazardous materials. Therefore, implementation of the 2021 LRDP would result in a **less-than-significant** impact.

Mitigation Measures

No mitigation is required.

Impact 3.10-2: Water Quality Impacts Related to Construction Activities

Construction activities associated with implementation of the 2021 LRDP would expose bare soil to rainfall and stormwater runoff, which could accelerate erosion and result in sedimentation of stormwater and, eventually discharge to receiving waterbodies. Construction-related projects in the LRDP area would be required to comply with the State Water Resources Control Board 2009-0009-DWQ Construction General Permit (CGP). Compliance with the CGP requires development of a Storm Water Pollution Prevention Plan (SWPPP) for projects disturbing 1 acre or more and the Campus Standards Handbook requires preparation of an Erosion Control and Sediment Control Plan for projects less than 1 acre. Compliance with the CGP and the Campus Standards Handbook would minimize erosion and sedimentation during construction. In addition, the design and operation of each new facility would adhere to UC Santa Cruz Post-Construction Stormwater Management Requirements (UC Santa Cruz Post-Construction Requirements). This program exists to ensure compliance with Central Coast Regional Water Quality Control Board Resolution R3-2013-0032. applicable laws and implementation of BMPs on the ground during construction. Therefore, implementation of the 2021 LRDP would not be expected to contribute substantial loads of sediment or other pollutants to stormwater or receiving waterbodies and would result in a **less-than-significant** impact.

Development under the 2021 LRDP would result in soil disturbance during construction of new facilities within the LRDP area. Removal of vegetation, excavation, grading, and stockpiling of soils for building foundations, roads, paths and driveways, and utility trenching would disturb soils that could accelerate erosion, especially during storm events if not properly managed. In addition to erosion and sedimentation, construction materials brought on site would also require containment from stormwater.

During construction, materials such as aggregate-base rock for roadway and parking area subgrade, sand bedding and backfill for utility lines, and base rock for building foundations would be brought to areas active construction sites. These materials could become exposed to stormwater and potentially result in runoff contamination. Areas of development on the main residential campus near karst features, such as sinkholes or swallow holes, could also potentially release contamination to groundwater. In addition, construction equipment that may contain toxic or hazardous substances, such as fuels, lubricants, oil, grease, and paint could also become exposed to stormwater runoff or to groundwater if they are not properly contained. Cumulative minor releases of contamination, or larger single releases (e.g., fuel spill) could result in adverse effects on surface and groundwater quality.

While potential stormwater related contamination during construction activities can pose a significant risk of impact to receiving waterbodies in the LRDP area, there are several layers of regulatory and programmatic elements that UC Santa Cruz is required to follow and implement when executing construction activities in the LRDP area. These include compliance with the SWRCB General Permit for Discharges of Stormwater Associated with Construction Activity (Construction General Permit Order 2009-0009-DWQ, the Stormwater Management Plan, Campus Standards Handbook, and the UC Santa Cruz Post-Construction Requirements, which are briefly described below.

For development under the 2021 LRDP that would disturb one or more acres of land, the contractor would be required to obtain coverage under the Construction General Permit before construction. To comply with the General Construction Permit, a SWPPP would be prepared and implemented with detailed measures to control soil erosion and waste discharges from project construction areas.

Imported fill and grading materials would be clean, chemically inert, and handled with appropriate BMPs to prevent contamination of stormwater. Erosion control barriers such as straw wattles, silt fences and mulching material would be installed. Implementation of these standard erosion-control measures would reduce the potential for soil erosion and sedimentation of stormwater runoff during construction.

In the unlikely event that dewatering for an individual project is required, the SWPPP would include a dewatering plan, which would establish procedures to treat groundwater pumped from the site before discharge, and to prevent sediment and contaminant releases into groundwater during excavation. The SWPPP would also include protocols to clean up releases if they occur.

For projects less than one acre, the Campus Standards Handbook requires preparation of an Erosion Control and Sediment Control Plan, which ensures that, as part of project specific analysis, appropriate BMPs are incorporated into the project for compliance with Campus Standards Handbook. During construction, campus inspectors routinely inspect the project to confirm compliance with the project plans.

The primary objective of the UC Santa Cruz Post-Construction Requirements is to ensure that UC Santa Cruz is reducing pollutant discharges to the Maximum Extent Practicable and preventing stormwater discharges from causing or contributing to a violation of receiving water quality standards in all applicable development projects. Performance Requirements include site design and runoff reduction, water quality treatment, runoff retention and peak flow management. Water quality treatment for applicable projects include Low Impact Development, Biofiltration and Non-Retention Based treatment systems that are designed to meet water quality performance requirements for new or existing runoff generated from impervious surfaces. Hydraulic sizing criteria for these treatment systems and runoff retention must manage stormwater equal to the volume of runoff generated by the 85^{th} or 95^{th} percentile 24-hour storm event, based on local rainfall data. Post-development peak flows discharged from the project site must not exceed pre-project peak flows for the 2- through 10-year 24-hour storm events.

With continued regulatory compliance and implementation of program elements designed to reduce construction related impacts to water quality, the impacts from construction related activities in the LRDP area would be **less-than significant**.

Mitigation Measures

No mitigation is required.

Impact 3.10-3: Alteration of Drainage Patterns and Increased Runoff

Development under the 2021 LRDP could alter drainage patterns, and increase the rate or amount of surface runoff, which could result in substantial siltation or erosion on or off site, and increase the amount of urban pollutants in storm water runoff, which could affect water quality. However, there are several layers of regulatory compliance and programmatic elements in place for new campus development that are designed to reduce runoff, peak flows and impacts to water quality and therefore, implementation of the 2021 LRDP would result in a **less-than-significant** impact.

Development under the 2021 LRDP would add new buildings, roads, paths, sidewalks, parking lots and other impervious surfaces to the LRDP area, which would generate more runoff compared to existing conditions, and could lead to more erosion in the drainages in the LRDP area and increased runoff of urban pollutants.

Pollutants, including sediment, entrained in urban runoff in high concentrations can adversely affect water quality and beneficial uses of the receiving waterbodies. As previously discussed, the campus SWMP ensures that UC Santa Cruz is legally fulfilling the requirements of its Phase II General Permit for Small Municipal Separate Storm Sewer System (i.e., Non-Traditional MS4 permit). Over the years UC Santa Cruz has constructed a variety of engineered facilities that convey runoff to the natural drainage channels that are designed to reduce erosion and impacts to water quality. These facilities include storm water detention basins and vaults, urban contaminant removal systems, biofiltration, engineered channels, catch basins, and bioswales. UC Santa Cruz also routinely performs street sweeping and parking lot cleaning, which also help reduce the amount of pollutants that enter storm water runoff. In addition to the SWMP, new campus developments must comply with the UC Santa Cruz Post-Construction Requirements, which are discussed in Impact 3.10-2, and are designed to reduce runoff, peak flow and water quality impacts. UC Santa Cruz is also considering options for providing a more comprehensive, integrated, and consistent approach to more consistently determine site-specific runoff changes related to individual drainages, as well as cumulative watershed changes that will inform appropriate site design measures (if required) and in conformance with SWRCB Phase II NPDES requirements.

As described above, UC Santa Cruz conducts an annual water quality monitoring program. Historically, water quality sampling and laboratory analysis was conducted at several surface water, groundwater and spring locations between 1989 and 2008. In 2009, the campus began monitoring storm water discharge from specific land use areas around campus as part of the SWMP. Currently, samples are collected from seven surface locations and two wells (WSW#1 and Upper Quarry Well) during the first significant precipitation event of the wet season. An analysis of historic and recent sampling does not show an increase in urban runoff pollutants over time and there does not appear to be any significant identifiable water quality impacts from campus activities.

With continued regulatory compliance and implementation of program elements designed to reduce runoff, peak flows and impacts to water quality, the impacts from altering drainage and increasing runoff in the LRDP area would be **less-than significant**.

Mitigation Measures

No mitigation is required.

Impact 3.10-4: Flood-Related Impacts

Development under the 2021 LRDP could alter drainage patterns in the LRDP area and would increase the rate or amount of surface runoff, which could exceed the capacity of storm water drainage systems, resulting in flooding on or off site. However, regulatory compliance and programmatic elements in place for new development in the LRDP area are designed to reduce runoff, peak flows and impacts to water quality and, therefore, implementation of the 2021 LRDP would result in a **less-than-significant** impact.

As previously discussed, UC Santa Cruz relies heavily on natural drainages to manage storm water in the LRDP area. As a result of the karst topography on the main residential campus, with sinkholes distributed in the channels and elsewhere throughout the central and lower campus, most storm water runoff from development reaches the karst aquifer by way of sinkholes and swallow holes and does not flow off the main residential campus. Flooding has historically occurred in the area of a few sinkholes on the main residential campus and southwest of the campus where Moore Creek flows through a culvert under an off-campus private road, Highview Drive.

Flooding on the main residential campus has historically been documented to occur at the locations of sinkholes that become inundated during significant precipitation events. Erosion has contributed to build-up of sediment in the sinkholes, which gradually limits their capacity to infiltrate runoff and can result in flooding. Three sinkholes identified in the *Stormwater and Drainage Masterplan* (Kennedy/Jenks Consultants 2004) were observed to be overflowing during the winter months of 2003 and 2004 following a wetter than average month of December. However, several of the completed storm water drainage improvements completed since 2005, which were included in the Infrastructure Improvements Project, have since diverted runoff from these critical sinkholes to mitigate sedimentation and overflow. There are no sink holes located on the Westside Research Park. Further, the portion of the Westside Research Park site that is located within the flood zone is limited to the far western edge of the property and is associated with Antonelli Pond. No development is currently anticipated within this portion of the Westside Research Park site.

New development under the 2021 LRDP could potentially cause new runoff to be diverted to sinkholes contributing to further build-up of sediment and loss of infiltration capacity. However, as noted previously, any development under the 2021 LRDP would comply with UC Santa Cruz Post-Construction Requirements for new development. Within the LRDP area, consistency with these requirements would involve retention of a substantial (i.e., 85th or 95th percentile storm event) amount of runoff and reduce peak flows. As noted previously, post-development peak flows may not exceed pre-project flows for the 2- through 10-year storm event. Compliance with existing regulations would effectively decrease the potential of sinkhole sedimentation and frequency of overflow by retaining and treating stormwater flows on-site. Therefore, the potential for flooding impacts related to sinkhole overflow would be less than significant.

Historically flooding in the Moore Creek watershed, which includes Westside Research Park, near Highview Drive was partly attributed to an undersized stormwater conveyance pipe at Highview drive, which has in the past become clogged with in-channel debris at the entrance of this pipe causing significant ponding of stormwater runoff behind the road embankment (Kennedy/Jenks Consultants 2004). As noted above, this pipe was replaced and no longer results in localized flooding. In general, UC Santa Cruz Post-Construction Requirements which require compliance with SWRCB Phase II NPDES requirements would manage peak flow rates and reduce sediment flow in the LRDP area. Potential surface runoff on the Westside Research Park would also be conveyed to the existing storm drainage system that serves the existing facility or retained on-site. In addition to UC Santa Cruz Post-Construction Requirements managing peak flow rates, karst features intercept most of the surface flow, even during extreme rainfall events. As a result, surface runoff from the main residential campus is usually low overall compared to other areas with similar rainfall. In addition, runoff from the Moore Creek watershed that does not enter the on-campus karst would be detained by the Arboretum Pond system, which would further reduce peak flows. The Arboretum Pond and the two basins created by the East and West Dams have a reported combined capacity of about 35 acre-feet below the elevation of the Arboretum Dam spillway pipe, the West Dam outlet, and the crest of the East Dam. This capacity is large enough to contain runoff from a 50-year storm if all existing sinkholes are plugged, or a 100-year storm if the existing sinkholes remain open (UCSC 2006). Because adequate storage capacity is available in the Arboretum Pond system, impacts related to flooding off campus would be **less-than-significant**.

Mitigation Measures

No mitigation is required.

Impact 3.10-5: Impacts to Karst Aquifer Supply, Recharge and Groundwater Quality

Potential impacts on groundwater that could result under the 2021 LRDP include: 1) reduced spring flows and lowering of aquifer water levels as a result of a reduction in recharge due to increased impervious surfaces, and as a result of potential groundwater extraction in the event that groundwater pumping is implemented to reduce demand for water from the City's water supply, and 2) impacts to groundwater quality from contaminated surface runoff. Impacts associated with new development on the karst aquifer would be **potentially significant**.

As previously described, the main residential campus is divided into two distinct hydrogeologic systems. Impacts on groundwater volume, spring flow and quality are discussed below separately for each of the two hydrogeologic systems.

North Campus

No groundwater extraction is planned for the upper/north campus aquifer, and therefore no groundwater extraction-related effects on the upper/north campus seeps and springs or on seeps, springs, and domestic water supply wells in the Cave Gulch area.

Impacts Associated with New Impervious Surfaces

Several currently undeveloped areas along the upper/north campus are proposed for development under the 2021 LRDP. New impervious areas would overlie the north campus groundwater system. Infiltration of rainfall is a significant source of recharge of the shallow aquifer on the north campus. Although this shallow groundwater is not extracted as a water source on the campus, it supplies water to springs and seeps located throughout the north campus and in adjacent drainages such as Cave Gulch and Wilder Creek. However as noted previously, UC Santa Cruz Post-Construction Requirements require new developments to retain a substantial portion (i.e., 85th or 95th percentile storm event) of pre-development runoff onsite, which would prevent a reduction in flow to springs and seeps. As noted previously and consistent with existing requirements, post-development peak flows would also not exceed pre-project flows for the 2- through 10-year storm event. As noted previously, UC Santa Cruz is also considering options to more consistently evaluate and determine site-specific runoff changes, as well as cumulative watershed changes that will inform appropriate site design measures (if required) and in conformance with SWRCB

Phase II NPDES requirements. This evaluation will help to inform appropriate design measures, including those related to new impervious surfaces. Nonetheless, due to requirements in place as part of the UC Santa Cruz Post-Construction Requirements, the impact within the north campus would be **less than significant**.

Mitigation Measures

No mitigation is required.

Central/Lower Campus

Impacts Associated with New Impervious Surfaces

UC Santa Cruz activities under the 2021 LRDP that could affect the karst aquifer in the central/lower campus include: 1) the addition of new impervious surfaces that could potentially alter recharge to the karst aquifer, and 2) construction of new buildings in areas of karst that could require the use of pressure grouting to stabilize soft soils. The combined effect of these activities could result in the reduction of groundwater levels, which in turn could potentially affect off-site spring flow.

Watersheds that overlie the karst aquifer include Jordan Gulch, Moore Creek and portions of the San Lorenzo-Pogonip Watershed. As previously discussed, much of the runoff is captured within the Jordan Gulch and Moore Creek Watersheds and infiltrated on the main residential campus via karst features (e.g., sinkholes and swallow holes) and as a result, little to no runoff leaves campus as surface flow. An increase in impervious surfaces would be substantial under the 2021 LRDP; however, as described in Impact 3.10-2, any new development must comply with the UC Santa Cruz Post-Construction Requirements which require the on-site retention of stormwater equal to the volume of runoff generated by the 85th or 95th percentile 24-hour storm event, and therefore would continue to recharge the karst aquifer and would not result in a net deficit. UC Santa Cruz is also engaging in planning that would be implemented to provide a comprehensive, integrated, and consistent approach to maintain the health and functionality of the existing karst system. This planning would also take into consideration development envisioned under the 2021 LRDP, current water infrastructure planning, campus projects currently under development, and UC Santa Cruz's goals and aspirations for watershed health, water sustainability and resilience to further ensure that net deficits or increases to the karst aquifer would not occur. As a result, impacts would be **less than significant**.

Mitigation Measures

No mitigation is required.

Impacts Associated with Pressure Grouting

In the past, UC Santa Cruz has employed pressure grouting to densify and stabilize soft soils associated with dolines that may be present under a building site by injecting cement grout into the soil. For this application UC Santa Cruz has conducted dye tracing studies to determine if specific building sites are hydrologically linked to springs and/or wells in the karst system and whether the introduction of grout could affect groundwater quality or flow rates at springs around the campus. Results of these previous dye trace studies conducted for building sites on the central campus confirmed no detections of dye at any of the off-campus monitoring points within each of the 18-week study periods, indicating that there are no rapid flow paths capable of moving water, grout, or other fluid from the dye injection sites to off campus springs. The grout is introduced near the ground surface, and not at or below the water table. The grout that is pumped is extremely stiff and does not flow without high pumping pressures. Extreme care is taken not to pump excessive amounts of grout into bedrock voids and crevices. Injection pressures are monitored during the grout placement to ensure that grout is not entering the marble but into the soil as intended. In some cases, if the pocket of soft soil being grouted is large, the grouting is stopped for a day or two to allow the grout to cure, which ensures that the grout is not lost to voids. Because of all these precautions, the pressure grouting program that the campus has employed has not resulted in impacts to water flow or degradation of water quality. However, impacts to water quality and/or spring flow resulting from this practice could be **potentially significant** if not adequately addressed.

Mitigation Measures

Mitigation Measure 3.10-5a: Procedures for Building on Karst Where Groundwater is Encountered and Where Pressure Grouting is Considered

For projects involving construction on karst as determined by the geotechnical investigation, if 1) groundwater is encountered beneath the building site, and 2) the proposed building foundation design includes pressure grouting, UC Santa Cruz shall complete a dye tracing study to confirm potential hydrologic connectivity of the building site with springs around the campus or campus wells. If the study confirms the building site to be hydrologically linked to springs and/or wells in the karst system, then alternative building foundation designs will be implemented.

Significance after Mitigation

Mitigation Measure 3.10-5a would ensure that campus pressure grouting practices necessary for stabilizing soft soils at karst building sites would not impact karst groundwater quality nor would it affect offsite spring flows, and therefore the potential impact would be **less than significant**.

Impacts Associated with Groundwater Extraction

The City of Santa Cruz supplies water for potable and non-potable uses to the campus. The campus may operate an existing well (WSW #1) located adjacent to the CASFS in Jordan Gulch to extract groundwater for non-potable use to off-set irrigation demand for the CASFS and the Arboretum, to reduce the campus's demand for water from the City's during drought years, or in the event that the City does not provide water to some portions of the campus (See Section 3.17, "Utilities" for more information on water supply and demand.) Existing annual demand for the CASFS and Arboretum is approximately 4.6 and 5.0 million gallons per year (MGY), respectively or 14.13 and 15.35 acre-ft/yr, respectively, and is projected to increase to 5.7 and 6.3 MGY, respectively or 17.5 and 19.35 acre-ft/yr, respectively, by 2040 (Sherwood 2020). As discussed above, well WSW#1 is capable of sustainably pumping approximately 92.5 gpm with very limited drawdown and no observable effects to off-site spring flow. This sustainable flow rate is equivalent to approximately 48.6 MGY or 149 acre-ft/yr (refer to Section 3.17, "Utilities" for more information on water supply and demand).

To analyze the effects of potentially withdrawing a total approximate volume of 29.5 acre-ft/yr (existing) or 36.9 acre-ft/yr (projected to 2040) a hydrogeologic water balance for the karst groundwater basin was prepared and is included as Table G1-2 (see Appendix G). The watershed area directly or indirectly recharging the on-campus karst aquifer consists of approximately 2,355 acres, of which approximately 672 acres are off-campus. A campus average annual rainfall amount of 41.4 inches has been estimated based on the stormwater tool to estimate load reductions (TELR) (Beck et al. 2017) modeling calculations for various 24-hr precipitation depths and the average annual number of days with measurable precipitation to represent the overall distribution and total average annual depths. The rainfall estimates were obtained from the PRISM Climate Group (2004) at Oregon State University (2NDNATURE 2020). Runoff percentage is estimated for each watershed based on the stormwater TELR modeling results (Appendix G), with a combined annual average of 8.6 inches. It's important to note that runoff analysis embeds losses to evapotranspiration. The estimated mean annual recharge for the karst aquifer under existing conditions is approximately 36.9 inches, or 7,668 acre-ft/ year. Of this total, based on historic spring and stream discharge data (which is summarized in Table 3.10-5), approximately 2,083 acre-ft/ year is surface discharge, including spring flow and groundwater-fed surface stream base flow. By subtracting the groundwater discharge from recharge, the groundwater budget yields a surplus of approximately 5,585 acre-ft/ year, which is assumed to leave the campus area as subsurface outflow. Additionally, the groundwater storage capacity within void spaces in the karst aquifer is estimated to be at least 3,000 acre-feet (Johnson and Weber & Associates 1989). Similarly and with respect to the potential for groundwater use to offset potable water demand, additional pumping up to the capacity of the existing well could result in approximately 110 additional acre-ft/year, which would result in very limited drawdown and no observable effects to off-site spring flow. The water that would be extracted would represent a small fraction of the total volume of groundwater in the karst aquifer (i.e., less than 5 percent, depending on rainfall conditions [i.e., drought]) and have negligible effect on the karst aquifer and spring discharge. therefore the impact from potential groundwater extraction from the karst for the land use areas described above would be **less than significant**. However, because subsurface flow in the karst aquifer system is not well understood implementation of Mitigation

Measure 3.10-5b would ensure that any long-term pumping from the aquifer would not result in a net deficit in aquifer volume or a significant reduction in spring discharge.

Mitigation Measures

Mitigation Measure 3.10-5b: On-Going Groundwater Level and Spring Flow Monitoring

If the existing well WSW#1 or a new groundwater well is used for extraction, UC Santa Cruz shall perform monitoring of water levels within that well and any other campus wells completed in the karst aquifer on a continuous basis when groundwater pumping occurs. UC Santa Cruz shall also conduct, at a minimum, monthly flow monitoring of those springs in the vicinity of the LRDP area shown to be connected to the well via a dye tracing study or other applicable testing method for the duration of groundwater pumping to determine whether there is any long-term decline in water levels or spring discharge. Monitoring of the springs shall also include an assessment of surface water resources (i.e., habitats, plant species, and wildlife species) for a distance of 500 feet downgradient from the daylighting of connected springs at least 30 days prior to and after groundwater pumping to determine if there are any changes or adverse effects in the condition of these resources that may be attributed to changes in spring discharge as a result of groundwater pumping.

If monitoring of water levels and spring flows indicates that UC Santa Cruz extraction of groundwater is contributing to a net deficit in aquifer volume, as indicated by a substantial decrease in average base flow water levels in any monitored wells or a substantial reduction of base flows in monitored springs, the campus will terminate or reduce its use of groundwater from the aquifer. A substantial decrease shall constitute observations of a continual decreasing trend in base groundwater water levels over a 3-5 year period coupled with a decrease in spring base flow conditions, beyond the standard deviation for any given spring, for a corresponding water year type. The average base water levels and base flows in springs will be defined through a statistical analysis of historic data, grouped by water year types. As new monitoring data becomes available, UC Santa Cruz will continually update the statistical analysis.

Significance after Mitigation

Mitigation Measure 3.10-5b would ensure that UC Santa Cruz monitors water levels and define average base water levels to ensure that extraction does not contribute to a net deficit in aquifer volume. In the event that extraction contributes to a net deficit, UC Santa Cruz would terminate or reduce groundwater extraction. Therefore, the impact to groundwater levels would be **less than significant**.