MEMO

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Date: April 2, 2021, revised April 19, 2021

Subject: Geomorphic and Hydrologic Opportunities in the WCA Priority Parcels along the San Gabriel Mountain Foothills

1. Introduction

The Watershed Conservation Authority (WCA) has asked Balance Hydrologics (Balance) for assistance in assessing potential geomorphic and hydrologic opportunities of land parcels that might be included as selection criteria as part of a broader effort of assessing parcels or parcel groups for acquisition prioritization along the San Gabriel Mountain Foothills. This memorandum summarizes landscape-scale geomorphic and hydrologic factors that were identified and assessed within the limits of this study.

The Opportunities Analysis below is based on available background materials and planning documents for the region, aerial imagery reconnaissance, and professional knowledge of geomorphic and hydrologic conditions typical of the area and supported by our broad experience working in Southern California landscapes. **Appendix A** "Glossary of Broad-Scale Geomorphic and Hydrologic Processes" provides definitions and context to geomorphic and hydrologic terms, concepts, and physical characteristics that are used to discuss and analyze acquisition prioritization for the parcels assessed along the San Gabriel Mountain Foothills.

2. Geomorphic and Hydrologic Opportunities Analysis by Parcel or Parcel Groups

Analyses were conducted to identify geomorphic and hydrologic opportunities specific to individual parcels or parcel groups, and which may be applicable to multiple parcels and/or parcel groups. Parcels and parcel groups discussed below are presented from west to east. Section 2 contains narrative discussions for each parcel or parcel group, and Section 3 contains a matrix that summarizes Section 2 information.

Key data used in parcel assessments included parcel boundaries provided as a .kmz file by WCA; current and historical aerial imagery available via Google Earth; USGS StreamStats; California fire perimeters; California DWR groundwater basin boundary online mapping tools; maps provided by WCA that included relative infiltration potential, historical hydrologic conditions, and existing conservancy lands; and various other sources as cited in the reference list.

Additional in-depth investigations relative to specific parcels or parcel groups, as the potential for acquisition becomes more clarified, would require field reconnaissance and supplementary desktop analyses to more thoroughly assess and/or quantify geomorphic and hydrologic opportunities and constraints.

Sierra Madre – Arcadia – Monrovia Foothills

A series of parcel clusters provide opportunities to achieve lateral (across the foothills) continuity along an approximate 3.2-mile trace of the San Gabriel Mountain Foothills and would collectively preserve most of the remaining open space lands in this area. Acquisition would increase lower foothill preservation as well as longitudinal (upslope/downslope) continuity with land held by other conservancies or the Forest Service. Seeps and springs along this stretch of foothill area were mapped in multiple locations in the late 1800's (Hydrology map). Preservation of natural seeps and springs, along with their recharge areas, would be an important aspect of maintaining a full range of natural hydrologic functions within these parcels. In addition, as with most parcels under consideration in this study, conservation of land close to development preserves important habitat remnants that may otherwise also become developed.

The group of parcels to the west (5760-027-014 and -013, 5761-001-001 and 5761-002-008) include headwaters and most of the area in three contiguous subwatersheds over approximately 104 acres. Parcels that include both sides of a stream and most or all of the watershed area provide opportunities for conservation of an entire ecosystem and allow for comprehensive restoration efforts, if needed.

These parcels burned in 1978 and 1993 (CalFire, 2020). Debris basins, installed to manage rock/mud/water "debris flow" materials that are generated during fire-flood-debris-flow cycles (see Section 6 glossary for more information), are present at the foothill-alluvial fan intersections downslope of parcels -014 and -013. The downstream debris basins create longitudinal discontinuities that will likely not change for the foreseeable future, and thus these two parcels would be lower on the priority list for preservation from a geomorphic and hydrologic perspective.

Parcels -001 and -008 include the headwaters of a subwatershed and a relatively large downstream alluvial fan area, and should be considered a high acquisition priority from a hydrologic and geomorphic perspective. Moreover, two seeps/springs were historically mapped within parcel -008 (Hydrology map). Conservation of headwaters to the alluvial fan/valley floor in these two parcels provides an opportunity to re-envision how post-fire flooding and debris flow could be managed. For example, restoration of a natural "wash" (see examples of washes as mapped in the Hydrology map) at the alluvial fan could be used to increase post-fire resiliency by creating a space where debris flow materials can deposit rather than managing this process with installation of a debris basin. Perhaps burns were not as thorough and/or post-fire response was different here compared to neighboring parcels/subwatersheds, which could explain why this area does not have a debris basin.

Parcel 5762-002-007 would include approximately 0.1-mile of stream distance upstream of Carter debris basin as well as surrounding subwatersheds to the east and west over approximate 36.4 acres. Acquisition of this parcel would provide additional lateral (across the foothills) and longitudinal continuity (extension of preserved watershed and its primary flowpath upstream/downstream). Conservation of lands upstream of debris basins allow many natural processes to remain largely intact. However, debris basins ultimately create a longitudinal discontinuity in the stream corridor that will likely not change for the foreseeable future, and thus, from a geomorphic and hydrologic perspective, parcels with debris basins would likely be considered lower on the priority list for preservation.

A set of parcels to the east (5764-031-002, 5764-001-019, 5765-002-014, 5765-002-0013, 8689-008-001, 8689-008-002) encompasses approximately 320 acres along 1.5 miles of lateral foothill expanse, starting from the eastern slope of the Sierra Madre Wash, including both sides of the Santa Anita wash downstream of the Santa Anita Dam, and abutting Arcadia Wilderness Park and Monrovia Wilderness Preserve.

Parcel -019 includes a similar opportunity as 5761-002-008: it may be possible to restore a wash on the available alluvial fan/valley floor area to increase post-fire resiliency (Fire map) related to flooding and debris-flow deposition. In addition, two seeps/springs were mapped in or near parcel -019. Parcels that include both sides of intermittent or perennial streams provide opportunities for conservation (including below Santa Anita Dam) of geomorphic and hydrologic processes, and allow for comprehensive restoration efforts, if needed or desired. Parcels such as this one that include both sides of a stream and most or all of the watershed area provide opportunities for conservation of an entire ecosystem. This parcel should be considered fairly high on the priority list for preservation from a geomorphic and hydrologic perspective.

Parcels 8503-004-038 and 8503-009-032 include the headwaters of a small western-facing subwatershed and two south-facing subwatersheds. Parcel 8501-012-007 is adjacent to Monrovia Wilderness Preserve and would preserve approximately 3 acres of an upper subwatershed tributary.

Bradbury Foothills

A contiguous parcel cluster of approximately 325 acres (8527-001-001, -012, -008, -009, -010; 8527-005-004 and -001) would add to lateral (across the foothills) continuity between Monrovia Wilderness Preserve to the west and Duarte Wilderness Preserve to the east, in addition to preserving lower-watershed corridors of two foothill tributaries that flow into Bliss Canyon debris basin. Approximately 1 mile of the western tributary would be preserved if parcels -012, -008, and -009 were acquired. Likewise, approximately 0.65 miles of the eastern tributary would be preserved if parcels 8527-005-001 and 8527-001-010 were acquired. This latter set of parcels would provide an opportunity to preserve continuous stream corridor, which promotes habitat preservation and allows for channel restoration possibilities, if needed. These parcels burned in 1980 (CalFire, 2020). Downstream discontinuity due to debris basins would put this parcel group somewhat lower on the prioritization list. In addition, the foothills downstream of these parcels are developed, so longitudinal connectivity to the alluvial fan/valley floor is detached from the watershed in this manner also.

Van Tassell Foothills

A contiguous parcel cluster (8689-006-007; 8610-023-001, -002, -003, -004 and -005; and 8602-002-012) of approximately 340 acres would extend conserved foothill land from Duarte Wilderness Preserve eastward and would encompass both sides of Van Tassel Wash to the Los Angeles Flood Control channel at the alluvial fan. Acquisition of parcels 8689-006-007 and 8610-023-001 would preserve approximately 1 mile of channel corridor and would result in complete preservation of the approximately 2 square mile watershed (including upper watershed

Forest Service land). Parcel -012 would extend preservation of two additional subwatersheds from headwaters to the alluvial fan/valley floor. Acquisition of parcel -004 would prevent mining encroachment at the ridge line (although that may already be prohibited). If Van Tassel were considered a fish refugia within the San Gabriel River corridor, the possibility of conservation of parcels along the flood control channel may move these parcels up in prioritization.

San Gabriel River

A series of parcels are located in the steeply-sided canyon of the San Gabriel River below Morris Dam and upstream of State Route 39 (San Gabriel Canyon Road) (8684-027-010, -004, -005; 8684-006-003; 8684-005-002; and 8684-028-023, -024). This parcel group contains floodplain/sediment bar features, riparian corridor and meander-bend river morphology (landscape shape) – features that typically perform important functions in a river system, such as sediment deposition, flood attenuation, infiltration, and aquatic habitat. Most parcels (all but -024) interface with the canyon and the river. The channel itself has downcut up to 7-10 ft since Morris Dam was completed in 1935 due to a lack of sediment supply (Kammerer, 2007), which has resulted in floodplain disconnection and has led to less flooding of the bar, less flood attenuation, and less sediment deposition and renewal during high flow events. Implementation of a gravel augmentation program on parcels 8684-027-004, -005, and -003, and 8684-005-002, could reinvigorate sediment transport processes and slow riverbed downcutting in this area.

Conservation of these parcels as well as 8684-028-023 and -024 would provide opportunities to restore stream channel-floodplain connectivity and preserve a significant meander bend morphology on the San Gabriel River that is not present in other local watersheds. Restoration elements could include lowering the surface elevation of the existing bar and creating a secondary low-flow channel that could be accessed by the public. Because the river has down-cut, the floodplain will likely need to be lowered as well, so that connectivity can be re-established. This would allow for a return to natural functionality and dynamics along the river-meander bend-floodplain-riparian corridor interface. During higher-flow releases from Morris Dam, this connectivity would help spread out high flow events; the floodplain would become inundated and act as a modest flood-control buffer. This process would encourage infiltration, water quality benefits, new terrestrial and flood habitat zones (i.e., high-flow refugia), and reinvigorate the riparian corridor. The San Gabriel River parcel group should be considered fairly high on the priority list for preservation from a geomorphic and hydrologic perspective.

Azusa-Glendora Foothills

Along the Azusa-Glendora Foothills from west to east, a series of parcels under consideration for acquisition are relatively spread out, but acquisition could create lateral connectivity across the foothills with other lands conserved by various groups. The 1968 Canyon Inn Fire and most recently the 2014 Colby Fire have burned these foothills.

Parcels 8684-024-035 and -001 are steeply-sloped foothills at the outlet of the San Gabriel River Canyon with a mostly western-facing aspect, but also include a portion of a subwatershed with a southern aspect that descends more gently. There is high infiltration potential at the base of these foothills relative to other areas because this was historically alluvial fan area where the San Gabriel River channel would move dynamically across the outlet during high flow events and deposit sediments that promote infiltration into the aquifer. Runoff onto the alluvial fan would promote recharge of the Main San Gabriel Basin aquifer via infiltration during storms, while also modulating runoff.

Parcel 8684-028-009 encompasses portions of five subwatersheds upslope of Hicrest Road. This may be the smallest-sized parcel available for acquisition that would preserve the highest concentration of continuity across multiple subwatersheds, and thus may rise to a higher priority from a geomorphic and hydrologic perspective. Preservation of headwaters would protect these streams from hydromodification impacts, and would be beneficial for water quality protection and stream corridor connectivity. Two seeps/springs appear to have been historically mapped at or near the base of this parcel (Hydro map). Conversely, two downstream debris basins result in channel discontinuity at the foothill-alluvial fan/valley floor interface. In addition, and as with most other parcels under consideration in this study, conservation of land adjacent to already developed lands can preserve important habitat remnants that may otherwise also become developed.

Parcels 8636-013-011 and -016 include the ridge tops and headwaters of two North Easley Canyon tributaries. Preservation of headwaters in these subwatersheds would be beneficial for water quality, stream corridor connectivity, and avoidance of hydromodification effects. A downstream debris basin results in channel discontinuity at the foothill-alluvial fan/valley floor interface.

Parcels 8636-016-017, -013-008, -013-007, and -019-021 include portions of four subwatersheds above Glencoe Heights Drive and Palm Drive. Preservation of longitudinal continuity in parcel -017 would provide passageway for flora and fauna (i.e., plants and animals) to migrate upstream and downstream. In addition, longitudinal connectivity allows geomorphic processes to occur naturally, which includes typical flooding and sediment transport as well as episodic responses to the fire-flood cycle. However, two downstream debris basins at the base of this parcel group results in channel discontinuity at the foothill-alluvial fan/valley floor interface.

Glendora-San Dimas Foothills

Large portions of the Glendora-San Dimas Foothills are underlain by volcanic andesitic and tuffaceous bedrock. These materials are typically layered and brecciated, and are generally more pervious than mixed metamorphic and granitic bedrock that underlays most of the core of the San Gabriel Mountains. Though not typically as pervious as alluvial fan deposits, volcanic flows can be areas of relatively high recharge rates (Infiltration map) and have high potential to support seeps and springs due to the layered geologic structure.

A series of small parcels, including 8658-017-031, -064 and a number of others, encompass the ridge separating two subwatersheds and portions of the intermittent stream channels. This appears to be the last ridge in the area that has not been developed. Acquisition of this group of parcels would conserve a ridge top between two subwatersheds as well as portions of each stream channel and would provide local connectivity to a much larger upslope area that includes the headwaters of these lower subwatershed streams. However, the parcels do not include both side slopes of either subwatershed, making this a lower priority parcel group.

To the east, a set of contiguous parcels encompasses approximately 900 acres, which would be the largest extent of adjacent parcels to be conserved if acquired as a group. Parcels include 8678-030-005, -006, -001, -029 and a number of others. Aerial imagery indicates that parcels 8678-030-033 and 8665-001-012 are already under development and a new debris basin has recently been built, which highlights how open spaces continue to be acquired, developed and will be managed into the future. Loss of open spaces to development along the San Gabriel Mountain Foothills leads to further hydrologic and geomorphic disconnection of watersheds. In the downstream direction, development can result in disconnection of the stream from the alluvial fan and the valley basin. In the upstream direction, development can likewise result in disconnection from upstream tributaries, including watershed headwaters that are important in maintaining water quality. In both cases, the result reduces habitat corridors for flora and fauna and reduces naturally cyclical processes (e.g., water quality processes, aquifer recharge, sediment transport, flooding).

Acquisition of remaining parcels would conserve much of the available area within several subwatersheds that drain to East Branch Big Dalton Wash, as well as the Sycamore Canyon subwatershed and an unnamed subwatershed to the east that contain foothill tributaries to San Dimas Wash, including parcels 8678-030-006, -005, -004, -001, -029; 8678-029-018 and -015. These relatively low-slope canyons, oak woodland vegetation and the volcanics-derived foothill soils act in unison as a sponge, which promotes recharge of the Main San Gabriel Basin aquifer via infiltration during storms while also modulating runoff. Infiltration potential in these foothill subwatersheds is high relative to other foothill areas (Infiltration map). One seep/spring was historically mapped downslope of these parcels, but not within the parcel group. Development of these parcels could lead to significant hydromodification effects. From a hydrologic and geomorphic perspective, acquisition of this parcel group would preserve headwater drainages, would conserve land on both sides of multiple stream channels thereby promoting preservation of riparian areas and providing stream restoration opportunities and would promote infiltration and aquifer recharge due to potentially highly porous layered volcanic bedrock (which is rare in the San Gabriel Mountain foothills). This parcel group could be considered relatively high priority for acquisition.

La Verne-Claremont Foothills

Parcels 8678-023-026 and -027 are located along a ridge top near the outlet of San Dimas Wash and parcel 8678-022-012 is located along the foothills to the east. Acquisition of these parcels would conserve areas that have a relatively high infiltration potential relative to other areas (Infiltration map), and in addition, development has not encroached entirely along the foothills-alluvial fan interface where infiltration potential is also high.

Acquisition of two parcels (8678-016-002, -021) in Marshall Canyon would provide an opportunity to preserve the majority of this subwatershed, including both sides of the creek, the riparian corridor and the headwaters. The eastern-facing canyon slope is steeper than the western-facing slope, likely a result of underlying geology, varying erosion rates and moisture patterns. One western-facing slope in the upper portion of the watershed shows signs of a recent mass wasting (landslide) event. The watershed is slightly less than a mile in length and generally about 0.3 miles in width, forming a narrow, linear canyon. The canyon opens into a relatively narrow valley floor approximately 0.3 miles long before exiting the foothills. The lower third of the watershed flairs out to the east as rolling hills rather than steep-sided canyon, likely a remnant alluvial fan. The relatively low-slope canyons, oak woodland vegetation, foothill soils and alluvial fan act in unison as a sponge, which promotes recharge of the Main San Gabriel Basin aquifer via infiltration during storms while also modulating runoff. The San Gabriel Valley Groundwater Basin is mapped beneath the Marshall Canyon valley floor as well under as the remnant alluvial fan to the east, which indicates that these parcels are particularly important for groundwater recharge. In addition, watersheds with soils or underlying geology that support higher natural infiltration rates may respond with relatively large changes in runoff rates when surfaces are paved or soils are compacted as development occurs, resulting in greater potential for impacts (e.g., erosion and downcutting) to downstream channel reaches, and greater reduction in rates of infiltration. An unnamed fire burned the upper watershed in 1960, and most of the watershed was burned in the 2002 Williams Fire. Historical aerial imagery suggests that the valley and most of the riparian corridor/upslope oak woodland along the east-facing hillslope did not burn in the 2002 fire. This subwatershed should be high on the prioritization list from a hydrologic and geomorphic perspective.

The geomorphic and hydrologic processes related to stream-runoff and sediment-production appear active and healthy in the Clara Oaks parcel 8669-012-005. The parcel covers a large portion of the watershed area on this hill, including the uppermost watershed ridges to the west and north. The somewhat-linear dissection features in the shallow canyons are ephemeral stream channels that actively transport runoff and sediment during and after rainfall events. Ephemeral runoff channels on the Clara Oaks alluvial fan (north and east of the ballfield) are areas with high infiltration potential and are connected to the historical Thompson Creek floodplain. The relatively low-slope canyons, oak woodland vegetation, foothill soils and alluvial fan act in unison as a sponge, which promotes recharge of the Main San Gabriel Basin aquifer via infiltration during storms while also modulating runoff. Small watersheds and headwater ephemeral channels such as these are highly susceptible to erosion and downcutting in response to land use changes. Natural infiltration capacities may be lost if the parcel were developed, because watersheds with soils or underlying geology that support higher natural infiltration rates may respond with relatively large changes in runoff rates when surfaces are paved or soils are compacted as development occurs, resulting in greater potential for impacts (e.g., erosion and downcutting) to downstream channel reaches, and greater reduction in rates of infiltration. Preservation of a large portion of the Clara Oaks watershed would preserve this functionally healthy watershed, including the full suite of hydrologic, geomorphic, groundwater recharge and ecological processes. The Clara Oaks parcel is unique and provides valuable natural resources and functions to the community, and would be considered relatively high on the prioritization list from a geomorphic and hydrologic perspective.

San Antonio Wash Foothills

The set of parcels (867-002-024) along the base of the foothills near Palmer Canyon are relatively unique with an easterly-facing aspect. This area appears to support somewhat denser oak woodlands on the canyon slopes, likely a result of less intense direct sunlight in the afternoon, during the hottest portion of the day. In addition, there is relatively high infiltration potential on the alluvial fan at the base of these foothills relative to other areas (Infiltration map), which would promote recharge of the eastern-most extent of the Main San Gabriel Basin aquifer via infiltration during storms, while also modulating runoff to neighboring communities. These foothills currently contribute runoff to Los Angeles County spreading grounds, and could be considered relatively high on the prioritization list from a hydrologic and geomorphic perspective.

3. Hydrologic/Geomorphic Opportunities Summary Matrix

Many factors contribute to geomorphic and hydrologic processes in watersheds, as noted in Appendix A. The broad-scale geomorphic and hydrologic characteristics and processes as outlined in Section 2 are summarized into a matrix in Table 3.1. The matrix focuses on individual or clusters of parcels, grouped from west to east, and assesses a subset of primary hydrologic/geomorphic characteristics that tended to create distinctions and/or prioritization differences, as recognized by desktop analyses, and as follows:

Headwaters/Water Quality Protection
Preservation of lands in the upper-most portions of watersheds (i.e., "headwaters", where streams originate) help maintain stream connectivity, refugia, and habitat corridors for flora and fauna. Headwaters are generally more sensitive to hydromodification effects in response to incremental development compared to lower watershed areas, so conservation of undeveloped upper watershed areas also provide more water quality benefits.

Infiltration Potential
Alluvial fans are located where the foothills meet the valley floor and slope flattens out. Fans typically have higher-than-average infiltration potential, especially along the fan apex nearest the foothills. Conservation of areas on alluvial fans are particularly important given the limited number of remaining open spaces of this type, where higher infiltration rates can help to replenish the local groundwater aquifer.

Longitudinal connectivity
Longitudinal connectivity is needed for geomorphic and hydrologic processes to occur naturally. These important processes include annual streamflow and sediment transport fluctuations, from low flow conditions to large precipitation events that can generate flooding and debris flows. In addition, channel continuity from the headwaters to the watershed outlet provides an important passageway for flora and fauna to migrate upstream or downstream via the channel corridor,

Riparian Corridor, Seeps or Springs
Conservation of riparian corridors is a key component of maintaining healthy stream ecosystems. Riparian corridors are important biodiversity "hot spots" that support a wide variety of flora and fauna in natural and impacted systems. Riparian corridors provide shade, refugia from predators, food and shelter, and provide a buffer between urbanized and more natural areas. Seeps and springs provide critical hydrologic support at specific locations during Mediterranean drought conditions every summer, as well as during extended droughts. Riparian corridors, wetland plants, terrestrial and aquatic species depend on these local surface-expressions of the groundwater table.

Other Notable Characteristics
Characteristics unique to or of particular note within a parcel or set of parcels were briefly noted in this column, if present.

Prioritization Score

Factors were individually scored based on desktop observations during the parcel assessment. Once scoring was completed, the number of "+'s" were tallied. A "High" relative prioritization score was assigned to parcels that scored 6 or more; a "Moderate" was assigned to parcels that scored between 4-5 and a "Low" was assigned to parcels that scored 0-3.

Table 3.1 Relative Prioritization Factors for Parcel Acquisition from a Geomorphic and Hydrologic Opportunities Perspective.

("++" = High Opportunity, "+" = Moderate Opportunity, "blank" = Low Opportunity)

	Headwaters/ Water Quality Protection	Infiltration potential	Longitudinal Connectivity	Riparian Corridor, Seeps or Springs	Other Notable Characteristics	Geomorphic/ Hydrologic Relative Prioritization Score
Sierra Madre-Arcadia-Monrovia Foothills						
5760-027-014 and -013	++		+	+		Moderate
5761-001-001 and 5761-002-008	++	++	++	++	Alluvial fan	High
5762-002-007	+			+		Low
5764-001-019	++	++	++	++	Alluvial fan	High
5764-031-002, 5765-002-014, 5765-002-0013, 8689-008-001, 8689-008-002	+		++	+		Moderate
8503-004-038 and 8503-009-032	+		+			Low
8501-012-007	+					Low
Bradbury Foothills						
8527-001-001, -012, -008, -009, -010; 8527-005-004 and -001	++			+		Low
Van Tassell						
8689-006-007, 8610-023-001, 8602-002-012	++	++	++	+	Tributary refugia for San Gabriel River flows	High
8610-023-002, -003, -004, -005	+	++				Low
San Gabriel River Canyon						

	Headwaters/ Water Quality Protection	Infiltration potential	Longitudinal Connectivity	Riparian Corridor, Seeps or Springs	Other Notable Characteristics	Geomorphic/ Hydrologic Relative Prioritization Score
8684-027-010, -004, -005; 8684-006-003; 8684-005-002	++	++	+	+	Meander bend/bar morphology	High
8684-028-023, -024	++	++	+	+	Meander bend/bar morphology, canyon walls	High
Azusa-Glendora Foothills						
8684-024-035 and -001	+	++				Low
8684-028-009	++	+	++	+	Continuity across multiple sub-watersheds	High
8636-013-011 and -016	++		+	+		Moderate
8636-016-017, -013-008, -013-007, and -019-021	+		+	+		Low
Glendora-San Dimas Foothills						
8658-017-031, -064 and others		++			Volcanics-derived bedrock and soils	Low
8678-030-006, -005, -004, -001, -029; 8678-029-018 and -015	++	++	+	+	Volcanics-derived bedrock and soils	High
La Verne-Claremont Foothills						
8678-023-026 and -027, 8678-022-012		++		+		Low
8678-016-002, -021	++	++	++	++	Includes large portion of the subwatershed	High
8669-012-005	++	++	++	++	Alluvial fan	High
San Antonio Wash Foothills						
867-002-024	+	++	+	+		Moderate

4. Regional Watershed Management Goals

Regional watershed management goals related to geomorphic and hydrologic processes include preserving, enhancing or rehabilitating water quality and quantity and functional habitats that support native species and natural processes. Functional habitats that are accessible to the public help to promote community health, and in addition, flood control is an important element of public safety. Such processes are present throughout the San Gabriel Valley Basin, from summit to sea.

As development pressures and urbanization continue within the San Gabriel Valley Basin, it has become increasingly important to preserve watershed functionality where possible. While most (but not all) systems on the valley floor have been heavily impacted by urbanization, multi-benefit opportunities to preserve, rehabilitate and restore active channels and riparian corridors should be pursued. In large part because the valley floor is highly urbanized, every opportunity should be pursued to rehabilitate or re-claim previously impacted areas, including channels and accompanying riparian corridors. In addition, low-impact development and best-management-practices strategies have been proven effective at improving infiltration and water quality at a local house-by-house scale in Los Angeles County (The River Project, 2018).

Development pressure is also present along the foothills, as illustrated by parcel assessments in this study. Preservation of parcels or parcel groups highlighted herein would help to maintain or possibly enhance water quality and quantity (infiltration/recharge into the aquifer).

5. Future Planning and Watershed-Scale Opportunities for WCA

The geomorphic/hydrologic analyses in Section 2, and as summarized in Table 3.1, provide opportunities that, if parcels could be preserved, would contribute to WCA goals. Acquisition and conservation of parcels along the San Gabriel Mountain Foothills would improve watershed continuity and connectivity with open spaces managed by other conservancies and the Forest Service. Recreational opportunities could be expanded and, in some cases, would allow for greater access directly from the valley floor/alluvial fan margin into the foothills and beyond, and which would contribute to overall community health and wellbeing.

In addition, Table 3.1 highlights diverse opportunities to conserve foothill lands that would contribute to subwatershed-scale geomorphic and hydrologic processes including conservation of longitudinal continuity, riparian corridors, seeps and springs, all of which support water quality, biodiversity and ecosystem integrity. Other opportunities include increased groundwater infiltration which supports water conservation and flood protection.

6. Limitations

This memorandum summarizes reconnaissance-level desktop analyses intended for generalized, landscape-scale planning purposes associated with WCA assessments of priority parcel acquisition. It is intended to identify possible broadly-based regional geomorphic and hydrologic opportunities, and is not intended as a comprehensive geologic, geomorphic, hydrologic or soils report for specific land parcels. Site-specific geomorphic and hydrologic factors in individual parcels should be assessed once preferred parcels are identified. This memo should not be considered as a comprehensive summary of site-specific parcels or of possible hydrologic opportunities and constraints at local or regional scales.

7. References

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Appendix A: Glossary of Broad-Scale Geomorphic and Hydrologic Processes

Our desktop-based analyses relied on supporting documentation provided by WCA and regional geology, soils, rainfall, and other relevant information, along with our professional and scientific knowledge of possible geomorphic and hydrologic processes associated with existing landscape elements in the parcels of interest. Below, we briefly define or discuss terms and concepts that, in a variety of configurations, form existing conditions along the San Gabriel Mountain Foothills, including within WCA territory.

The definitions and other background/supporting materials contained in this Appendix provide an accounting of broad-scale concepts that were considered and, in some cases, utilized to provide context to the study analyses. It is important to note that the information presented below does not constitute exhaustive discussions but rather offers a brief perspective on geomorphic and hydrologic topics that are likely to be relevant to this study, which could be utilized as baseline information for future studies.

Geomorphically-valuable watershed characteristics include a dynamic floodplain corridor with lateral connectivity between the channel and overbank areas; longitudinal connectivity via instream habitat including pools, riffles and other morphologic channel features; an appropriate sediment supply and range of particle sizes; refugia in channels where aquatic organisms can shelter from predators, high flows, and high temperatures; and habitat and erosion protection associated with a healthy riparian corridor and channel complexity.

Likewise, hydrologically-valuable watershed characteristics include geologic units and soil types that promote infiltration and support recharge to local or regional groundwater, as well as contribute to seeps and springs that support ecologically important refugia pools or channel sections during dry seasons. Healthy upper-watershed areas can help absorb rainfall, attenuate downstream flooding and promote water quality. Mid-watershed reaches provide longitudinal connectivity vital to stream and ecosystem health. Alluvial fans that interface with toe-of-foothill slopes are especially important areas that spread and infiltrate runoff into the Main San Gabriel Valley aquifer. Connectivity of a channel to its floodplains throughout the watershed also contributes to slowing of flood flows, infiltration, and prevention/removal of detrimental water constituents, thus benefitting water quality.

A.1 Hydroclimatic Conditions

<u>Precipitation</u> averages approximately 18 to 25 inches a year along the San Gabriel Valley Foothills (Arguez et al., 2010; PRISM Climate Group, 2021). More broadly, precipitation has been reported to range from about 15 to 31 inches with an average 19 inches in the San Gabriel Valley basin (DWR, 2004). The Mediterranean climate pattern of the region receives precipitation during the “rainy season”, approximately December through March, with “summer drought” conditions of little to no precipitation characteristic of other months. Precipitation generally falls in the form of rain in the lower foothill and valley elevations and sometimes as snow in the upper mountain elevations.

- Rainfall rates can vary by elevation and storm direction, and higher elevations in mountains generally receiving more rainfall than foothills or valley.

  - The orographic effect tends to "squeeze" precipitation (as rain or snow) out of clouds as mountain elevation increases; the San Gabriel Valley Foothills are likely to have more rain than the valley but less rain than at higher elevations.
  - In addition, in hills and/or mountains, rainfall rates are generally higher from the direction a storm approaches from (i.e., windward or upwind side) and the side of a slope on the other side of the storm (i.e., leeward or downwind side) generally experiences less rainfall, in large part due to the orographic effect.
- Rainfall intensity can vary by storm type.
  - Atmospheric River (AR) events tend to deliver intense, high-magnitude rainfall to localized areas in "bands" that can be successive but tend to move through the area relatively quickly (CW3E, 2021).
  - Broader, low pressure systems tend to deliver moderate to high quantities of precipitation over more extended periods of time.
- Rainfall rates and moisture conditions can vary by land aspect.
  - Rainfall is stochastic, which means that rainfall magnitude, duration, and intensity can vary from one location to another, even within a single watershed.
  - Water retention from rainfall and atmospheric conditions (fog, etc.) tends to be greater along north-facing and east-facing slopes compared to south-facing and west-facing slopes because of generally lower evapotranspiration rates due to the trajectory and aspect of the sun.
  - Similarly, deeper crevasses and canyons generally retain more moisture than upslope canyon walls or watershed ridges because of the differences in sun exposure and thus evapotranspiration rates.

Conservation of areas with higher rainfall averages or lower evapotranspiration rates could help preserve infiltration and aquifer recharge capacity, as well as contribute to localized perennial streams and/or refugia pools in deep canyons (via bedrock infiltration and subsequent baseflow during dry season conditions).

A.2 Geology

The entire San Gabriel Mountain range is uplifting rapidly (at the geologic timescale), which results in steep terrain that is susceptible to rapid erosion. Fault lines along the San Gabriel Mountain Foothills include the Sierra Madre Fault Zone and many minor faults (Morton and Miller, 2003). Cracks, joints and fractures brought about by faulting and natural weathering processes provide conduits for water to infiltrate into bedrock (Ofteringer et al., 2019). Seeps, springs and dry-season baseflow are hydrologic expressions of water-bearing bedrock aquifers.

Geologic units along the southern San Gabriel Mountain Foothills include (Jennings et al., 2010):

- Mesozoic granitic rocks, unit 3
- Precambrian igneous and metamorphic rock complex
- Tertiary volcanic flow rocks, unit 8 (Southern California Basin)

- Pre-Cenozoic metasedimentary and metavolcanic rocks undivided
- Miocene marine rocks
- Quaternary alluvium and marine deposits, which lie along the toe of the foothills, generally (but not always) downslope of the parcels

Alluvial fan deposits along the toe of foothills at the edge of the San Gabriel Valley represent the accumulation of sediments transported from mountain terrain and deposited as slopes decrease. Alluvial fans, especially near the apex (i.e., as channels exit from the foothills into the valley), are typically areas with high infiltration and high recharge potential due to relatively thick layers of unconsolidated gravel and sand. Basin deposits further into the Valley contain sand and silt intermixed with less-permeable clay and silt layers, and have somewhat lower recharge potential than at the alluvial fan apex (DWR, 2004), but generally higher recharge potential than in the foothill watersheds as long surface soils are not covered or altered by urbanization.

However, it is important to note that areas underlain by relatively high-permeability bedrock units can support deep recharge that supports summer baseflow and/or pockets of water refugia in dry conditions. These areas are susceptible to changes in hydrological functionality due to development in the foothills. Coarse sandstone and conglomerates, highly fractured granitic rocks, karstic limestone, and areas underlain by volcanic tuffs or layered basalt/pyroclastic flows can exhibit high infiltration rates relative to other areas. Parcels overlying these types of materials would be higher priority for preservation relative to parcels over areas of shale/slate, sparsely fractured metamorphic rocks, or other materials with lower potential rates of infiltration.

A.3 Soils

Soil variations that include properties consistent with high infiltration (recharge) rates or that experience frequent inundation would hold opportunities for conservation from a hydrologic perspective. Soils on mountain slopes are typically poorly-formed, and lack higher rates of recharge capability. Alluvial fans, and in some cases canyon valleys, contain deposited sediments that can form soils with a higher infiltration capacity.

In the San Gabriel Mountain Foothills, underlying geology is generally a better indicator of infiltration potential. Soils in the San Gabriel Valley downslope of the foothills have been identified as typically silt or sandy loam, but are covered to a great extent by impermeable surfaces associated with urbanization, which diminishes or removes the natural capacity of those soils and underlying geology to promote rainfall runoff infiltration into the local groundwater aquifer. However, especially where existing flow paths are not channelized and concreted, and where other pervious surfaces exist, there are opportunities for substantial aquifer recharge (as evidenced by numerous aquifer recharge spreading grounds on the valley floor).

A.4 Watershed and Stream Characteristics

Two geomorphology textbooks, Leopold et al. (1964) and Knighton (1998), were utilized to describe various watershed and stream characteristics, below, unless otherwise noted.

<u>Watersheds</u> range from small- to large-sized, and are often nested, with a series of smaller subwatersheds making up a larger watershed. The San Gabriel River watershed is large, and is

made up of smaller watersheds (i.e., tributaries or subwatersheds)[1] with channels that join the primary ("mainstem") channel in the mountains. In addition, there are a series of smaller, often individual, foothill subwatersheds that drain onto the valley floor and flow to the mainstem (or historically distribute across and disappear/infiltrate) into the vast, connected alluvial fan that covers the San Gabriel Valley floor.

In summary, tributaries/subwatersheds contribute flow and sediment from nested portions of land to a larger watershed. Historically, the Los Angeles River, the Rio Hondo and the San Gabriel River variably joined together or flowed apart depending on storm sequences and other natural processes such as fire followed by flooding, which played a role in how the channels moved dynamically across the alluvial fans and larger coastal plain of the Los Angeles Basin – which provides an important reminder of how dynamically these channels responded to water and sediment pulses under natural conditions, and how these systems can still respond under urbanized conditions.

Topography

Ridges form the uppermost extent of a watershed boundary.

Canyons are steeply-sided mountain slopes that start at the ridge line and end at the stream channel. Stream channels form along the bottom of canyons to move precipitation runoff downstream from upper portions (both upstream and upslope) of a watershed. In Southern California's semi-arid climate, perennial streamflow, refugia pools and/or seeps or springs may be found in some canyons. Riparian corridor vegetation along channel extents may be supported by subsurface moisture during dry conditions. Canyon streams provide critical habitat for riparian vegetation and animals that utilize the riparian corridor and aquatic habitat.

Alluvial fans are located at the toes of the foothills (where the foothills meet the valley floor), have a gentle slope that continues downstream, and are typically areas with higher-than-average infiltration potential (especially the fan apex near the foothills).

Valleys such as the San Gabriel Valley are located distal to (moving away from) alluvial fans, are lower-in-slope than the alluvial fans and are generally where the larger groundwater aquifers are found. The San Gabriel Valley basin is highly urbanized with limited remaining open space where infiltration can replenish the local groundwater aquifer; spreading grounds are utilized for this purpose and other areas where natural channel bottoms and/or open space is available may be suitable for increased infiltration efforts.

[1] Tributaries to the San Gabriel River include the San Gabriel East Fork, West Fork, and North Fork as well as Fish Canyon, San Dimas Creek, Big Dalton Wash, Little Dalton Wash, San Jose Creek, Walnut Creek, Thompson Creek, and others. Subwatersheds include all foothill streams and their watersheds that drain directly from the foothills to the alluvial fan/valley floor, rather than including watershed area that is not directly local to the alluvial fan/valley floor. Almost all parcels analyzed in this study would be considered subwatersheds (perhaps except for the meander bend in the San Gabriel River below Morris Dam), and this is the term primarily used throughout the text.

Groundwater
The Main San Gabriel Valley Groundwater Basin is an adjudicated[2] aquifer. The Main San Gabriel Basin Watermaster agency administers water rights adjudicated in 1973 and is devoted to the management and protection of groundwater resources within the watershed and groundwater basin (Watermaster, 2021). The WCA territory and the parcels under consideration for acquisition lie within and upslope of (and thus may contribute recharge to) this aquifer.

Stream position in the watershed
Preservation of lands in the upper-most portions of watersheds (i.e., "headwaters", where streams originate) help to maintain water quality, stream corridor connectivity, and habitat corridors for animals and vegetation. Land adjacent to streams in the mid- to lower-portions of a watershed may be more fragmented, with impacts such as upstream/downstream connectivity and/or urbanization effects. Conservation of land closer to development can preserve habitat remnants and partial stream corridor connectivity.

Channel network density
Channel network density is defined as the total channel length divided by the area of a watershed and depends on climate (precipitation), geology, soils, vegetation and other physical characteristics of a catchment. A watershed with a higher density may exhibit higher erosion potential and sediment yield, whereas a lower density may be less prone to highly erosive and episodic events such as post-fire flood flows that generate rock/mud/water "debris" flows.

Stream channel form and pattern
Planform (i.e., "aerial map view") geometry characteristics of streams include straight sections, bends and meanders.

Cross-section geometry characteristics include the width, depth and shape of the river channel and its relationship to the floodplain.

> Channel incision, which can be a typical condition in urban settings, leads to disconnection of the channel from the floodplain, and may contribute excess sediment to downstream reaches as the channel downcuts.

Longitudinal profile characteristics include channel slope and locations of deeper and shallower sections. In-channel features support various habitats that terrestrial and aquatic species depend on.

In-channel features
Pools are generally deep sections of a channel where water moves slowly.

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[2] Per the California Department of Water Resources, groundwater adjudication is a court-determined arbitration process to settle disputes over legal rights to a defined area of groundwater. The court decides who the water rights owners are, how much groundwater those rights owners can extract and how the groundwater areas will be managed A "watermaster" manages the ownership of rights and water use. https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management/Adjudicated-Areas.

Riffles are generally shallow sections of a channel where water moves quickly. Riffle sediment-sizes can range from gravels to cobbles and boulders.

Glides are transition zones between pools and riffles that are not as deep as pools, where water moves more quickly than in pools but less quickly than in runs.

Runs are transition zones between pools and riffles that are not as shallow as riffles, where water moves more quickly than in glides but less quickly than in riffles.

Bedrock/boulder steps or waterfalls are abrupt vertical changes in channel elevation caused by bedrock that is resistant to erosion, or boulder/wood clusters; step height can vary from approximately 1 foot to hundreds of feet in vertical elevation.

Sediment bars are depositional areas within channels where water velocities slow down enough for sediment that is transporting in the water column to settle out. Sediment sizes and supply depend on upper watershed sediment production and can constitute a mix from sand to boulders. Bars are often located along the inside arc of a meander bend, but are also found in straight channel sections along the bank or in mid-channel areas. Upstream dams block the natural sediment supply, which often causes channel downcutting. Downcutting is a result of a lack of suitable sediment quantity and quality that channels dynamically adjust to over long rainfall/runoff cycles and other naturally occurring events (especially the flood and fire cycle so common in Southern California).

Connectivity to floodplain
Areas adjacent to a channel include floodplains, terraces and canyon slopes and walls. Floodplains are expanses of area that lie closest to a channel and are regularly flooded during higher flow events under natural conditions. Floodplains within steeply-sided canyon slopes and walls are generally confined to sediment bars. Floodplains lower in the watershed, downstream of steep canyon reaches and along the valley floor, are commonly many times wider than the stream channel. Terraces are remnants of previous floodplain elevations when stream channel elevations were higher and/or are abandoned floodplains where the active channel dynamically moved away from that area during higher flow events.

Channel incision
Channel incision[3] into sediments is a typical channel-evolution process that may occur naturally over geologic timescales, or over more rapid timescales (decadal) in response to land-use changes such as urbanization and development in a watershed. Channel incision becomes more pronounced and occurs at a higher rate when channel form or hydrology is changed at or upstream of a particular location.

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[3] See discussion of incision in the lower San Gabriel Canyon downstream of Morris Dam in the Kammerer, M., 2007, Appendix B1: Hydraulic Conditions and Preliminary Feasibility of Improvements at the El Encanto Property Site of the El Encanto Azusa River Wilderness Park report prepared by BlueGreen and others, for the Watershed Conservation Authority. In this case, accelerated channel incision is a result of Morris Dam sequestering sediments and moderating flow brought about by land use changes, hydromodification, and flood control practices. There are many other forms of land use changes, hydromodification, and flood control practices that impact stream channel processes.

Longitudinal connectivity
Channel continuity from the headwaters to the watershed outlet provides an important passageway for animals to migrate via the channel corridor, upstream or downstream, depending on species, climate conditions, time of year, and other factors. Plants also migrate along the channel corridor, generally via seed dispersal and stem propagules. Longitudinal connectivity also allows geomorphic processes to occur naturally, which includes low to moderate flooding and sediment transport on an annual basis as well as very large flood events, including episodic responses to heavy rain such as AR events that occur post-fire and generate debris flows.

Riparian corridor condition
Riparian corridors are important biodiversity "hot spots" that support a wide variety of plants and animals in both natural and impacted systems. Riparian corridors provide shade, refugia from predators, food and shelter for a myriad of terrestrial and aquatic animal and plant species. In addition, riparian corridors provide a buffer between urbanized and more natural areas. Conservation of riparian corridors is a key component of maintaining healthy stream ecosystems.

A.5 Proximity to Other Protected Lands

Existing protected lands in the area include San Gabriel Mountains National Monument, State Parks, County Parks, various City Parks and open space lands owned by numerous municipalities, local conservancies, and the Watershed Conservation Authority. Hydrologic and geomorphic values associated with proximity to these other protected lands would include preservation of stream channel and adjacent riparian corridor connectivity and opportunities for larger restoration projects that extend beyond an acquired parcels' boundaries.

A.6 Connectivity to Upstream and/or Downstream Natural Channels

Stream corridors that have not been highly impacted, and that are connected to natural open spaces, whether located in the upper watershed, mid- or lower-watershed, or channels downstream of the San Gabriel Foothills, have more potential to maintain natural stream morphology and function than those that have been more highly impacted, and could be candidates for acquisition and stream corridor restoration as needed.

A.7 Hydromodification Susceptibility

Hydromodification is generally defined as hydrologic changes to runoff and/or stream conditions in response to land-use or other alterations within a watershed, and is often most associated with changes due to urbanization. Typical responses to hydromodification include rapid downcutting of a channel and bank erosion. Channels that are more susceptible to these impacts include those that lack resistant baselevel control, such as hard bedrock or robust stabilizing vegetation. Smaller watersheds are typically more susceptible than large watersheds because even small changes in land-use impacts a relatively larger percentage of the available watershed area. Watersheds with soils or underlying geology that support higher natural infiltration rates may respond with relatively large changes in runoff rates when surfaces are paved or soils are compacted as development occurs, resulting in greater potential for impacts (e.g., erosion and downcutting) to downstream channel reaches, and greater reduction in rates of infiltration.

A.8 Parcel Size and Position Relative to a Stream

From a hydrologic and geomorphic perspective, parcels that span both sides of a stream channel and include the riparian corridor would be considered higher priority for acquisition than parcels that do not include riparian areas or cover only one side of a stream channel. Conservation of channel-spanning parcels would provide the ability to preserve more ecosystem functions, habitat and hydrologic connectivity, as well as more stream restoration opportunities. In addition, parcel or parcel group size may be a prioritization factor, simply because the more area conserved the better for hydrologic, geomorphic and ecological functions. However, specific characteristics unique to a smaller parcel or parcel group may also be considered as having higher priority potential, depending on the parcel. For example, regardless of parcel size: a historically-mapped seep or spring could be important to preserve; a parcel with high infiltration potential may be appropriate for acquisition; and a subwatershed headwater area may be a suitable parcel for conservation.

A.9 Potential for Water Quality Improvements/Protection

Upper watershed areas that include headwaters would provide more water quality benefits than lower watershed areas for parcels that are currently undeveloped, due to the proportion of area within a watershed that can be protected from hydromodification effects if development occurs in the future. However, acquisition of currently developed or partially developed parcels, especially those in areas of heavy industrial or commercial uses, may provide key opportunities for improving water quality by converting back to more ‘natural’ land-use or through incorporation of water quality treatment features or facilities.

A.10 Natural Springs, Seeps and Wetlands

Parcels identified as containing or near natural springs/seeps and wetlands should be considered high priority for protection. In addition to protection of the hydrologic features themselves, an equally important priority is to protect the upper watershed areas that supply and sustain these features through direct surface runoff and/or by infiltration to local groundwater.

A.11 Groundwater Dependent Ecosystems

Ecosystems that depend on groundwater seeps or springs, or on a shallow groundwater table, such as wetlands and canyon refugia pools during drought conditions, are relatively rare and should be considered highly desirable and important areas for conservation (Klausmeyer and others, 2018)[4].

A.12 Dams

Dams create longitudinal discontinuities within stream corridors. Dams block natural streamflow and sediment transport. Natural high flows are generally muted, and low flows are often extended through Mediterranean “drought” months when the stream would generally be dry or have discontinuous pockets of flow and/or pools under natural conditions. A channel downstream of a dam may begin to downcut and/or erode laterally because of the loss of the natural sediment supply. Moreover, flow releases do not mimic natural fluctuations, which allows flow to concentrate and erode the channel bed and banks. In addition, impounded water behind a dam inundates area that was once part of a channel corridor, the floodplain and even the

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[4] GDE Pulse (codefornature.org).

canyon walls. Sediments that transport into a reservoir fall to the bottom of the reservoir. Accumulation of sediment causes loss of capacity; a dam meant for water supply or flood control can become obsolete and hazardous because of sedimentation.

A.13 Fire History/Management

Natural and anthropogenic factors that affect the fire-cycle in Southern California include annual Mediterranean dry-season drought conditions, rainy season drought conditions that can persist for multiple years (i.e., mid-2010's), episodically-infrequent high flow events (especially in the first 1-3 years post-fire), lightning strikes, human-caused fire, and fire suppression. Another factor is the Santa Ana winds, which blow "off-shore" (from land to the ocean) and are recurrent annual winds (up to approximately 100 miles per hour in the mountains) and cause sharp drops in humidity, which can lead to rapidly spreading fires due to high winds and low humidity.

When steep-sided mountain slopes burn, vegetation that once provided root strength and soil cohesion also burns, while the fire itself can cause infiltration rates to decrease (via soil hydrophobicity). If heavy rainfall occurs within the first few years post-fire, when slopes are mostly non-vegetated or newly revegetated, post-fire rock/mud/water "debris flows" can be triggered, which can produce devastating consequences to downstream life and property. This sequence of natural events occurs on a regular, cyclical basis in Southern California[5] (Kean et al., 2019).

A.14 Debris Basins

Many debris basins have been built along the San Gabriel Mountain Foothill canyons as well as in upper watershed areas. The basins have been built to protect homes and urban encroachment that has occurred over the past 100 years along the upper portions of alluvial fans and into the canyons. The basins are meant to protect downstream urbanization from debris flows, particularly in the 1-3 years post-fire when steep slopes are denuded and prone to mass erosion. Heavy rainfall during this vulnerable time prior to revegetation can mobilize significant amounts of rock and soil that, mixed with rainfall runoff, can result in loss of property and life. Debris basins create longitudinal discontinuities by preventing natural sediment transport processes that would move rock and mud downstream onto the alluvial fans and into the valley. The basins are designed to trap sediment but not water, and are cleaned out as quickly as possible post-debris flow in anticipation of the next storm event that generates more sediment (whether tomorrow or years from now).

A.15 Climate Change

Natural processes and the ecosystems that depend on watershed hydrology may become harder to sustain as temperatures increase and rainfall becomes more variable due to global warming and climate change. Conservation of ecosystems will be an important approach, such as acquiring an entire subwatershed or the headwaters of a subwatershed, and should be considered a higher priority for acquisition than parcels that would conserve a middle or lower portion of a subwatershed.

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[5] The December 2017 Thomas Fire burned steep hillslopes in the Santa Ynez Mountains in Santa Barbara County. Fire was followed by intense rainfall that triggered massive mudflows that resulted in the death of 23 people and damages to numerous homes, buildings and infrastructure.

A.16 Federal Emergency Management Agency (FEMA) Flood Information

Flood Insurance Rate Maps (FIRMs) [6] are developed by FEMA and used by Federal, State and local governments to identify where streams will flood at a statistically derived flood recurrence interval (generally a 1% and 0.2% chance of flooding in a given year[7]) based on a combination of flow records and modeling or approximation methods.

Flood control channels and levees maintained by the Los Angeles County Flood Control District confine most flows coming from the San Gabriel Mountain Foothills, such that flooding is generally not considered a risk for densely urbanized downstream areas. Thus, in general, the flood risks associated with subwatersheds in the San Gabriel Mountain Foothills are not defined by FEMA. However, the San Gabriel River corridor downstream of Morris Dam and upstream of the spreading grounds is shown as a Zone A with a 1% chance of flooding each year. And a few subwatersheds and the San Dimas Wash downstream of the foothills are shown as Zone X with a 0.2% chance of flooding each year. In addition, potential effects of climate change could alter the magnitude of large floods and thus could affect FEMA-designated areas. Other factors that affect flood magnitude include the fire-flood-debris flow cycle.

[6] FEMA-derived flood extents (if any) for a specific stream and surrounding area can be found at https://msc.fema.gov/portal/home. Enter a city or address and explore the interactive National Flood Hazard Layer online viewer. Zoom in to an area of interest and use the legend to understand whether a specific area has an identified flood hazard according to FEMA.

[7] Often referred to as the 100- and 500-year events, respectively, the current identification preference is to use the statistical enumeration.