Appendix 5 - Alternatives Considered by WSAC (Table 1)

Consolidated alternatives (CAs)					Water convention alternatives (WCAs)**			
#	Name	Description	Water source	Status*	#	Author and comments	Assumptions	Reasoning
CA-01	Peak Season Reduction	Develop programs to decrease peak season demands through peak reduction or peak-demand shifting	Conservation (mandated)	WSAC members formed a working group that is exploring ways to enhance peak season water savings. (Ongoing Evaluation)	WCA-69	SCWD: Peak season reductions – 10%, 25% and 50%	Develop measures to reduce peak season demand by 10%, 25%, and 50%. Measures include, but are not limited to, turf replacement, water restrictions, seasonal water pricing, and permanent water rationing.	Reducing peak season demand would match available supply to actual demands, reducing the need to draw water from aquifers or Loch Lomond. This change would carry over more stored water for dry years.
CA-02	Water-Neutral Development	Implement a demand offset program required for new development to offset new demands	Conservation (mandated)	Examined in detail by the Water Commission within the past year, and still under consideration. Concerns about potential low level of net savings, and the potential high cost burden focused on developers, contractors, home buyers and renters. (Preserved for future consideration.)	WCA-03	SCDA: Water-Neutral Development	Water neutral develop focuses on development "bringing" new water, for example, by fronting costs for water efficiency retrofits and crediting saved water against new demands for a 1:1 offset.	Other water suppliers in NorCal have successfully used development charges to "buy" conservation by other customers.
CA-03	Water conservation measures	Implement Program Crec (Maddaus Water Management, September 30, 2014, Table 4)	Conservation (voluntary)	Actively examined and endorsed as a likely part of WSAC recommended portfolio. WSAC considering ways to expand, enhance, and expedite projected water savings. (Currently included.)	WCA-20	McGilvray (9): Implement Conservation	The general conservation measures include: a water loss control program, installation of advance metering infrastructure (AMI), water budget based billing, public information program including various outreach and education approaches, a customer billing report and service, free water surveys and fixture replacement incentives, landscape ordinances and water budget based rates, among other measures.	As implemented in other locations, water conservation measures included in the City's proposed plan have improved efficient water use in other communties in Ca, in the US and in other countries.
					WCA-22	SCDA: Conservation Education		
					WCA-65	zNano: Conservation rebate program		
					WCA-68	SCWD: Program C from Long-Term Water Conservation Master Plan		

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CA-04	WaterSmart Home Water Reports	Use this software to promote conservation and efficient water use	Conservation (voluntary)	Included within Program Crec (CA-03), hence not being examined as a separate item. (Currently included.)	WCA-04 WCA-16	WaterSmart: Home Water Reports Gratz: Maximize Conservation Behavior	Making water users more aware of their water use through automated notifications would encourage more efficient water use.	Newer technologies allow automated tracking and analyses of water use and report directly to user, to increase their awareness.
CA-05	Home Water Recycling	Package automatic treatment system suitable for single family home or condo or multi-family development; recycles gray water for toilet flushing and landscape irrigation; requires dual plumbing.	Decentralized (graywater)	Examined using vendor-supplied cost and performance data, for application to new single familty residential (SFR) construction. Given low level of outdoor irrigation and toilet flushing volume projected for new SFRs in Santa Cruz, a very limited water savings for high cost. (Preserved for future consideration).	WCA-39 WCA-66 WCA-70	Garges: Residential Gray-Water zNano: Onsite Water re-use Home Water Recycling	This is an infrastructure-based solution that recycles all the gray water in the home. It is automatic and operates without active homeowner management.	Several alternatives proposed to use gray water recycling in residential units to reduce potable water demands, especially for flushing toilets and landscape irrigation including CA Plumbing Code compliant facilities and installation (zNano approach could apply to commercial entities as well).
CA-06	Landscaping, Capture, Reuse	Use gray water for irrigation; minimize irrigation for lawns; capture and use rainwater for domestic, non-potable	Decentralized (rainwater, graywater)	Set aside for WSAC purposes because the City already offers a program to support irrigation applications of graywater (and that program has received very limited participation from customers). In addition, empirical evidence (although limited) does not indicate any savings in potable water use in homes with graywater irrigation. Allowed under CA Plumbing Code. Addressed in City's overall water conservation/demand management planning; likley has high cost per unit of water saved. (Preserved for future consideration).	WCA-01 WCA-21	Markowitz: Landscaping, Capture, Re-use SCDA: Climate Appropriate Landscape	This is an infrastructure-based solution that recycles both captured rainwater and gray water in the home. It is automatic and operates without active homeowner management.	Several alternatives proposed to capture both rainwater (e.g., roof runoff) and gray water use for landscape irrigation.
CA-07	Deepwater Desalination	In cooperation with Soquel Creek Water District, sign up for water delivered from the Deepwater Desalination Project at Moss Landing. Work with SqCWD to create the transfer facilities for potable water conveyance. Upgrade SCWD distribution system to accept water transferred through SqCWD.	Seawater	Considered by WSAC as one of the potential "Building Blocks" for a future portfolio. (Preserved for future consideration.)	WCA-19 WCA-36 WCA-37 WCA-67	McGilvray: (11) Seawater Desal Aqueous: Desalination (non-membrane) Brown: Zero-emission Wave energy Tanaka: Energy Efficient Desal	City participation in the Deepwater Desalination Project would allow the City to benefit from economies of scale and permitting efficiency while potentially seeing lower energy for desalting. Establishing a data center cooling system at the Moss Landing site would heat water prior to desalting, reducing required pumping energy. The facility would use a deeper intake to minimize environmental impacts. Also	Several alternatives propose to use desalting seawater as an opportunity to produce water regardless of rainfall and avoid future water shortages during supply shortfalls. Several technological alternatives were also offered.

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#	Name	Description	Water source	Status*	#	Author and comments	Assumptions	Reasoning
					WCA-72	Seawater desalination--Deepwater Desalination	environmental impacts. Also includes technilogical alternatives.	
CA-08	Water from Atmosphere	Extract water from the air to offset other demands	Moist air	Dropped from near-term consideration based on information revaling high cost and relatively small yields. (Preserved for future consideration).	WCA-38	DewPoint : Atmospheric Water Generation	The relative humidity in Santa Cruz is often high owing to its sea-side location. Existing technologies can extract purified water from humid air.	These alternatives use the same technology to draw water from the air. Note that the sizes for the two systems may differ radically. The technical team is waiting on further manufacturers' information for more detailed evaluation. We have requested additional vendor data but to date we have received no such data. Even at a larger scale, the economics likely are unacceptable owing to the high energy use.In addiitona, high energy use would not be palatable in Santa Cruz.
					WCA-77	SKYH2O		
CA-09	Winter flows capture	Capture winter flows for treatment and storage or infiltration	Winter flows	Under active consideration by WSAC as a potential source of water to meet various future needs and approaches, including possible use for in-lieu or active aquifer recharge. (Currently included.) Modeled extensively by Fiske with multiple Confluence runs to estimate future potentially available water.	WCA-29	Malone: Stormwater capture	Owing to local rainfall and runoff patterns, these alternatives offer potential to capture high flows and divert for treatment and/or groundwater recharge.	Several alternatives advocate that the City use its existing water rights to divert more flow during higher runoff periods and store it either in open reservoirs or as infiltrated groundwater, to cover dry-period demands. This CA encompasses those WCAs.
					WCA-60	SCDA: Watershed Restoration		
					WCA-63	Smallman: Water Skate Parks		
					WCA-71	SVWD: Quarry storage/GW recharge at Hanson Quarry		
					WCA-74	McGilvray: Additional Pipeline--Felton Diversion to Loch Lomond		
					WCA-76	Bixler: Olympia Quarry		
					WCA-31	McGilvray: (3) Water Capture and Transfers		
CA-10	Water Reuse for aquifer recharge	Produce CAT water at City WWTP and pump to SVWD for aquifer recharge (IPR--Indirect Potable Reuse).	Reclaimed water	Use of purified recycled water under consideration by WSAC members in several possible types of applications, including aquifer recharge. (Currently included.)	WCA-44	McGilvray: (8) Tertiary Treatment, Re-use	The City now discharges millions of gallons of wastewater effluent to the ocean outfall that could potentially be diverted and reused as stored groundwater. California Division of Drinking Water now allows addition of highly purified wastewater effluent to aquifer, for recovery later as potable water.	Several alternatives advocate diverting wastewater effluent after high level tertiary treatment (recycled water) and addition of such recycled water to aquifer, to recharge depleted aquifers and storage it for subsequent reuse. Recycled water would be a highly reliable water source with drought resiliency.
					WCA-62	Smallman: (17) Recycled Water		
					WCA-64	Weisz: Water Recycling		

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#	Name	Description	Water source	Status*	#	Author and comments	Assumptions	Reasoning
CA-11	Water reuse for direct potable	Produce CAT water at City WWTP and pump to GHWTP for treatment and distribution system addition, a Direct Potable Reuse (DPR) alternative.	Reclaimed water	Use of purified recycled water is being considered by WSAC members in several possible types of applications, including direct potable reuse. (Currently included.) Still under active consideration.	WCA-11 WCA-46 WCA-64	SCWD: Water Reuse McKinney: Water Reuse Weisz: Water Recycling	The City now discharges millions of gallons of wastewater effluent to the ocean outfall that offers potential for reuse. Highly purified wastewater effluent could be combined with raw water, then treated at the City's WTP. California Division of Drinking Water is developing regulations to allow use of a treated combination of highly purified wastewater effluent and other raw water resources for potable water, without routing the CAT effluent through an aquifer system prior to its reuse. Note that DPR is not prohibited by DDW. The City could apply for approval for a specific project.	Several alternatives advocate diverting wastewater effluent after high level tertiary treatment (recycled water). This alternative would take advantage of improved, multi-barrier treatment and modified regulations, to recycle effluent directly into GHWTP. Recycled water would be a highly reliable water source with great drought resiliency.
CA-12	Water Reuse for indirect potable	Produce CAT water at City WWTP and pump to Loch Lomond.	Reclaimed water	Use of purified recycled water was under consideration by WSAC members in several possible types of applications, including reservoir augmentation at Loch Lomond and potential seawater intrusion barrier. (Preserved for future consideraton.)	WCA-44 WCA-52 WCA-62 WCA-64	McGilvray: (8) Tertiary Treatment, Re-use Paul: (17) Detention Tub String Smallman: Recycled Water Weisz: Water Recycling	The City now discharges millions of gallons of wastewater effluent to the ocean outfall that offers potential for reuse. Highly purified wastewater effluent could be combined with raw water, then treated at the City's WTP. California Division of Drinking Water is developing regulations to allow use of a treated combination of highly purified wastewater effluent and other raw water resources for potable water.	Several alternatives advocate diverting wastewater effluent after high level tertiary treatment and addition of such recycled water to Loch Lomond Reservoir ultimately for subsequent treatment at the GHWTP and reuse. Recycled water would be a highly reliable water source with great drought resiliency.

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#	Name	Description	Water source	Status*	#	Author and comments	Assumptions	Reasoning
CA-13	Water Reuse for non-potable	The City would pump the Title 22 unrestricted effluent north through a new pipeline aligned along the railroad right of way, with turnouts to irrigate up to about 1,300 acres on private land and leased land. The City would use wells on ag land to produce water for treatment at GHWTP.	Reclaimed water/ groundwater	Examined closely by WSAC and set aside due to uncertainty about reliable availability of groundwater for exchange, or willingness of farmers to participate. (Preserved for future consideration.)	WCA-09 WCA-40 WCA-41 WCA-45 WCA-43 WCA-64	Ripley: Reuse for Agriculture Gratz: Recycled Water for Irrigation McGilvray: (1) Recycled Water for Irrigation McKinney: Additional Wells and WTPs McGilvray: (6,7) Pipelines Along RR Line Weisz: Water recycling	Coastal farmers north of the City irrigate for about 6 months of the year, mainly drawing from groundwater. The City discharges millions of gallons of wastewater effluent to the ocean outfall that offers potential for reuse with additional treatment. More recent work by Pueblo Water Resources (May 2015) has shown that the potential groundwater resource that the City could return in exchange for recycled water is more limited than previously assumed. Hence, this CA is less attractive than previously assumed.	The City would treat water to CA Title 22 unrestricted reuse standards and pump it up the coast through newly installed pipelines, for farmers to use in lieu of groundwater for irrigation. The City would drill new wells and construct new pipelines connecting to the North Coast Pipeline. It would extract groundwater to supplement its other sources during droughts.
CA-14	Desal using Forward Osmosis	Use seawater desalting through a Trevi forward osmosis (FO) system. This alternative's other components would match those for seawater desalting. The alternative has several outstanding issues, e.g., Trevi technology and other FO technologies are still in their infancy and being tested at a pilot scale. As described, Trevi would require a lower grade heat source for separately drawing the solution from the potable water but the alternative description did not designate a source for lower grade heat.	Reclaimed water or seawater	Examined by WSAC and Technical team, and technology not believed to be effectively proven at this time for reliable application to City-level desal or recycling needs. (Preserved for future consideration.)	WCA-13	Trevi: Forward Osmosis Desalination (separate FAQs and technical memorandum summarize FO in its various incarnations and its implementation status around the world)	This alternative assumes that the City would implement desalting using FO, an emerging technology. Since FO technology and implementation is in its infancy, this CA will not be developed further.	This alternative captures the intent of WCA-13 Trevi Forward Osmosis. Since the Trevi FO is still at the research/demonstration stage, this alternative has not developed further. If future testing and implementation by other entities prove its value, it could replace RO if the City was to select and implement Alternative CA-12.
CA-15	Desalination using Reverse Osmosis	This alternative for initial comparison would use seawater desalting through a new reverse osmosis desalination facility to produce about 2.5 mgd for addition to the City potable water supply. This alternative's components and development would match those for the previously proposed scwd2 desalination facility. The City would own and operate the facility and would use the water produced year round. Excess water would allow the City either to idle the Live Oak wells for conjunctive-use aquifer recovery or to undertake Live Oak well operation in an ASR mode to	Seawater	Under consideration by WSAC, such as in a version of the scwd2 desal project previously examined by the City. (Currenty included.)	WCA-12 WCA-19 WCA-36 WCA-37 WCA-67	Sustainable Water Coalition: Desalination McGilvray: (11) Seawater Desal Aqueous: Desalination (non-membrane) Brown: Zero-emission Wave energy Tanaka: Energy Efficient Desal	Desalting seawater using RO is a well proven technological approach that requires substantial capital investment and has high O&M costs. Desalting seawater is not impacted by drought conditions.	Several alternatives propose to use desalting seawater as drought relief to avoid future water shortages during supply shortfalls.

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#	Name	Description	Water source	Status*	#	Author and comments	Assumptions	Reasoning
CA-16	Aquifer restoration/storage	The City would sell treated water to SqCWD during normal and wet years. SqCWD would use the transferred water for either groundwater recharge or demand reduction and conjunctive use. SqCWD would sell pumped groundwater water to City during droughts. The City also should have improved production from its Live Oak wells.	Winter flows	Actively examined and under consideration as a potential key component of a WSAC recommended portfolio, both as in lieu recharge and as ASR.	WCA-08	Paul: (13) The Lochquifer Alternatives	The City has diversion rights and treatment capacity that are not utilized during low demand periods of the year. The local aquifers offer storage opportunities given their significantly reduced levels.	The City could treat more water during low demand periods and inject it in its own well field and/or transfer treated water to SqCWD and/or SVWD for aquifer storage.
					WCA-28	Malone: Regional Water Exchanges (also possibly addressed through CA-11)		
					WCA-49	Paul: (14) Upgrade Water Intertie		
					WCA-59	SCDA: Enhance Existing Infrastructure		
					WCA-10	SCDA: Regional Aquifer Restoration		
CA-17	Expand Treatment Capacity	Add a new 14-mgd water treatment plant (WTP) (pretreatment for turbidity control and membrane filtration) near the Tait Street Diversion to produce treated water that would be piped directly into the distribution system. It would increase capacity to divert to Loch Lomond and produce additional water for aquifer recharge.	Winter flows	Examined by WSAC and the technical team, and set aside as less advantageous than other alternatives (in terms of costs and water supply benefits). (Preserved for future consideration.) In the future City likely will evaluate further to compare with upgrades to GHWTP.	WCA-06	McKinney: Expanded Treatment Capacity	The City would add a new 14-mgd WTP at the Tait Street Diversion and pipe treated water directly into the distribution system. During periods when treatment exceeds City demands, the City would send the water to the Live Oaks wells, the Soquel Creek Water District, and/or the Scotts Valley Water District for aquifer storage and recovery. During droughts the City would draw more water from its wells and "import" water from adjacent districts.	This alternative captures the intent of both WCA-06 McKinney: Expanded Treatment Capacity, and WCA-27 Malone: Enhanced Storage and Recovery. These alternatives propose capturing additional surface flow from the San Lorenzo River to divert to storage for retrieval later by the City. An added benefit of this CA obviated the need to upgrade the GHWTP since a new, modern, and seismically durable WTP would be constructed.
					WCA-27	Malone: Enhanced Storage and Recharge		

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#	Name	Description	Water source	Status*	#	Author and comments	Assumptions	Reasoning
CA-18	Off-stream water storage	Convert Liddell Quarry into 650 MG reservoir, filled with water from City North Coast diversions; use stored water to offset water demand during drought	Winter flows	Several potential sites for on-stream or off-stream surface water storage were considered by WSAC and the technical team. All suggested sites presented geo-technical and other related issues, rendering them unsuitable for surface water storage. (Preserved for future consideration). (e.g., development over Karst formation--North Coast sites-- and large landslide potential--Hansen Quarry site)	WCA-05 WCA-26 WCA-30 WCA-32 WCA-33 WCA-34	Bevirt: North Coast Quarries (modified to include diversion of water from City existing sources) Fieberling: expand storage (addresses off stream storage) McGilvray (2): Quarries for Water Storage SCWD: Zayante Dam and Reservoir Smallman: Reservoirs Smallman: Storm Aquarries	The City would convert Liddell (Bonny Doon) Quarry into a surface-water reservoir to create a new storage facility. Water diverted from the City's existing surface-water rights would fill the reservoir during average-rainfall and wet years. This CA would use portions of the existing North Coast Pipeline in combination new pumping systems, reservoir inlet/outlet pipeline, and re-contoured and lined reservoir. More detailed technical review for this CA has shown that it presents significant geotechnical risks that the City could not easily mitigate. It also includescurrently unquantifiable risks concerning water rights and regulatory approvals for additional water diversion.	This CA captures the intent of WCA-05 Bevirt: North Coast Quarries (modified to include diversion of water from City existing sources); WCA 26 Fieberling: Expand Storage (addresses off-stream storage); WCA-30 McGilvray (2): Quarries for Water Storage; WCA-32 SCWD: Zayante Dam and Reservoir; WCA-33 Smallman: Reservoirs; and WCA-34 Smallman: Storm Quarries. These WCAs propose to store diverted surface water in surface reservoirs. Although this CA does not capture all of the specifics for each WCA grouped in this CA, it incorporates the high-level idea of off-stream storage drawing water under the City's existing water rights. The quarry site used in the CA was selected because would likely reduce environmental impacts and political issues associated from construction of a dam in an existing channel and degrading existing undisturbed habitat.

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#	Name	Description	Water source	Status*	#	Author and comments	Assumptions	Reasoning
CA-19	Ranney Collectors	Use Ranney collectors with a 12.9-mgd capacity (maximum capacity allowed under the current City of Santa Cruz [City] diversion permit), installed near the City's Felton diversion to draw water allocated under the City's existing water rights. Water drawn through the collectors would have greatly reduced turbidity and allow continuous refilling of Loch Lomond while also operating the GHWTP. It would produce additional water for aquifer recharge.	Winter flows	Ranney collectors have been examined by WSAC and the technical team, and may have value as a cost-effective approach to improving water quality (e.g., reducing the costs of treating high turbidity winter flows to potable standards). Under consideration as possible mechanism to facilitate use of winter flowsas part of GHWTP improvments. Ranney collectors currently have challenges because the City does not control potential sites and does not have site-specific geotechnical information. (Currently included).	WCA-07	McKinney: Ranney Collectors on SLR (requires a storage component to be a viable alternative)		
					WCA-42	McGilvray: (4,5) Upgrade Water Treatment	The City's ability to divert is restricted occasionally when high turbidity is experienced in the existing raw water diversions as a results of treatment restrictions at the GHWTP.	Using Ranney collectors (well screens installed horizontally many feet underground) to capture SLR flows would allow the City to maximize its diversion since diversions would not be impacted during periods of elevated turbidity in the raw water. Note that this alternative also might include a new WTP adjacent to the Tait Street diversion, with low turbidity water from the Ranney collectors contributing to a more cost-effective new WTP.
					WCA-48	Paul: (12) Diversion Alternatives		
					WCA-49	Paul: (14) Upgrade Water Intertie		
					WCA-57	Paul: (23) Loch-Down Alternatives		
CA-20	Interagency Cooperation/County Water Authority	Establish Santa Cruz County Water Authority to manage water resources development and use for public agencies and private diverters and groundwater users	Institutional/ administration	WSAC is actively considering various alternatives that would include (require) regional collaboration and associated agreements across the various water departments and agencies in the region. Establishing a new "Authority" has not been actively considered (beyond the scope of WSAC). (Preserved for future consideration).	WCA-14	Gratz: Regional Water Authority	This alternative would create a County Water Authority (CWA) to maximize cooperation among local governing authorities.	A CWA could take advantage of system efficiencies and funding opportunities that require multi-agency coordination.
					WCA-15	Smallman: Regional Water Authority		
					WCA-18	McGilvray: (10) Regional Collaboration		

*Status described as Currenlty Included, Ongoing Evaluation, Preserved for Future Consideration
**Several WCAs were not considered in great detail by WSAC for various reasons. Those WCAs can be found in Table 2.
updated October 20, 2015