Open Source: Water Innovation

LEVI STRAUSS & CO.

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Levi Strauss & Co. Water<Less™ Program

Garment finishing

Garment finishing is the last step in making a product and can involve many wet processes to create a unique look. The specific steps used will vary depending on the desired aesthetic of the finished garment. The 21 Water<Less™ techniques outlined in this document demonstrate effective methods to eliminate, combine, or reduce one or more wet processes.

Rigid

Raw, rigid denim is the purest expression of Water<Less™ in that it requires no water for finishing either in garment or fabric form. The only time a rigid garment will touch water is in dyeing. No further wet treatment is applied to the garment for softening, desizing, color loss, etc. When the rigid Water<Less™ technique is used, no water savings are accrued.

Fabric

In 2015 we expanded our Water<Less™ program from garment finishing in laundries to fabric dyeing in the mills.

In Fall 2015, we launched the first-ever Levi's® Water<Less™ fabric, which results in 65% water savings compared to traditional indigo rope dyeing which equates to an average of 6 liters of water saved per garment.

In Spring 2016, we added a second Water<Less™ fabric to our portfolio. It is a non-denim fabric and the process is based on a more efficient dyestuff. The process results in 100% fixation of the dye to the fabric so the 14 washing boxes/steps required in traditional dyeing are saved. The process results in 60% water savings compared to traditional pad-steam non-denim fabric dyeing which equates to around 1.7 liters saved per garment.

Double Count Control

The Double Count Control is a table specifying the Water<Less™ techniques that should not be combined (pages 27-28). Certain techniques have the same water-saving effect, so such techniques should not be combined. For example, if Ozone is used, other techniques that are concerned with removal of the bleach step should not also be used, such as Foam Bleach, Sky Bleach, Neutralize Bleach in Same Bath, Ozone Mist, and Low Liquor Ratio Bleach.

Technique Usage

Of the 21 techniques, not all are used in every season. Many factors determine which type of Water<Less™ process may be used to achieve a desired finish. For instance, a particular look may not be achievable with existing Water<Less™ techniques or certain vendors may not have adopted the techniques yet. The figures used in this document come from 2015 production data.

This table ranks the top five techniques that save the most water per jean.

Rank	Water Savings per Jean (L)	Water<Less™ Technique
1	12.0	Ozone
2	12.0	Ozone Mist
3	11.8	Combine desize & stonewash / enzyme wash
4	11.1	Combine desize, enzyme wash, & bleach
5	10.8	Combine enzyme & softener

This next table ranks the top five most frequently used techniques.

Frequency of Use Rank	Water Savings per Jean (L)	Water<Less™ Technique
1	5.9	Remove desize
2	5.8	Spray potassium permanganate on raw garments
3	11.8	Combine desize & stonewash / enzyme wash
4	0	Rigid[1]
5	2.4	Low liquor ratio for stone wash

[1] Rigid denim is the purest expression of Water<Less™ techniques in that it requires no additional water for finishing. However, it does not accrue savings since it is an unwashed finish.

The Water<Less™ Techniques

Remove desize step

Water savings counted: One desize bath
Average water savings: 5.9 liters / jean
Frequency of use: High

When it's applied, "sizing," a starch, increases yarn weavability. The starch remains on the yarn through weaving, cutting, and sewing of a garment. Traditionally removing the starch, "desize," during garment finishing required an enzyme bath, a strong oxidizing or reducing agent, and then one rinse. That's two wet baths in total.

Modern sizing uses modified, water soluble synthetic starches. That means the starch will wash out in any wet bath, eliminating the need for wet baths in some cases. Still, many vendors continue to follow traditional desizing steps.

Levi Strauss & Co. teaches suppliers how water use in both baths can be reduced for many finishing formulas. In the case of a heavy weight fabric or a fabric that is sensitive to abrasion, a rinse step might still be necessary. Since vendors apply the technique in different ways, they may save one or two baths. Therefore, we conservatively count the water savings from only one bath, the desize bath.

Additional notes

- Some mills still use non-water soluble starches. Generally, encouragement from a brand partner can help a mill switch to a water-soluble starch.
- Challenges with shrinkage may arise.

Ozone

Water savings counted: A bleach bath and a generic neutralization bath
Average water savings: 12 liters/ jean
Frequency of use: Moderate

Traditionally used to clean up garments, ozone, a powerful oxidant, has been used in finishing for some time. As a Water<Less™ technique, higher concentrations of ozone achieve more pronounced lightening effects, effectively replacing many uses for wet bleach baths.

Lightening a garment with a wet bleaching agent typically requires three wet baths: a bleach bath, a neutralize bath, and a rinse bath. If ozone use comes in the middle of a finish formula, it saves all three baths. If ozone use is the first step in a formula, it only saves two baths because the garments need to be wet before being loaded into the machine. Since vendors apply the technique in different ways, they may save two or three baths. Therefore, we conservatively count the water savings from only two baths, the bleach bath and a generic neutralization bath.

Additional notes

- Ozone can be used on indigo or black sulfur fabrics.
- Use of ozone requires up-front investment in the ozone machine and the generators, along with safety training for workers.

Foam dye / tint

Water savings counted: One generic dye bath minus 1 liter per kg of garment
Average water savings: 5.7 liters / jean
Frequency of use: Low

A concentrated dye solution applied as a foam instead of in a typical wet dye bath involves what is essentially a very low liquor ratio and a rinse bath. There's a maximum of a 1:1 liquor ratio. A typical wet dye bath involves a dye bath and a rinse, and potentially a fixative bath, though fixative might also be added directly to the dye bath. Therefore, this technique saves the majority of one bath: a generic dye bath (minus 1 liter per kg of garment, expressed in liters).

Additional notes

- Some fabrics may not be receptive to foam application.
- Pigments may also be applied using foam.
- Machines must be rubber lined rather than lined with plastic or metal.
- The technique can be used on a wet or dry garment.
- This technique creates a specific random dye aesthetic so the technique must be designed into the finish from the start.
- The technique can require additional labor.

Foam bleach

Water savings counted: One generic bleach bath minus garment load weight (in liters)
Average water savings: 5.6 liters / jean
Frequency of use: Low

Foam bleach is applied in foam form rather than in a typical wet bath and maintains a maximum 1:1 liquor ratio. Foam bleaching replaces the normal bleach bath and is still followed by a neutralization and rinse bath.

Additional notes

- Please see considerations for foam dye / tint.

Spray softener

Water savings counted: One soft wash bath
Average water savings: 4.4 liters / jean
Frequency of use: Low

Traditionally, softener is applied to garments in a wet bath to achieve a softer hand feel. With this technique, we apply undiluted softener in a tumble dryer with a spray instead.

Additional notes

- The softener selected must be compatible with indigo.
- This technique can also be used in a washing machine.
- If used in a dryer, be sure the dyer filters are kept clear.
- Technique works best on light to medium shades and for twill fabrics since crocking may occur.

Low liquor ratio for stonewash

Water savings counted: ½ stonewash bath
Average water savings: 2.4 liters / jean
Frequency of use: Moderate

Stonewash typically involves both an abrasive solid like pumice stones and water loaded into a washing machine. We have found abrasion is equally effective simply with less water in the washing machine.

Additional notes

- Back staining may occur if this technique is not properly applied.
- Low liquor ratio stonewash can be difficult in a belly washer machine.
- It is not recommended to use a liquor ratio below 3:1.
- Advances in enzyme and dispersant chemistry make this technique possible.

Sky Bleach / Rags Bleach

Water savings counted: One generic bleach bath
Average water savings: 6.2 liters / jean
Frequency of use: Low

Sky bleach/ rags bleach is an undiluted bleach solution applied to rags which are then tumbled with garments, without any water in the machine. Acid wash or "moonwash" is the same process with the only difference that the carrier for the bleach solution is pumice stones or sponges instead of rags or towels. This technique replaces the traditional bleach bath. A neutralization and rinse bath still follow the technique. Therefore, is saves a single bath, the generic bleach bath.

Additional notes

- This technique creates a specific aesthetic so the technique must be designed into the finish from the start.
- Given the desired variability in the aesthetic, this technique creates unique garment finishes for each garment.
- The type of rag used depends on the desired effect. Towels, sponges, foam cubes, socks, tennis balls, etc. are all possible media.
- Garments should be loaded into the machine wet to create a smoother, even lightening effect.

Soft rigid

Water savings counted: One soft wash bath
Average water savings: 4.4 liters / jean
Frequency of use: Moderate

Achieve the soft hand-feel effect by tumbling the garments in a dryer with balls/bottle caps/etc. to soften the fabric without water.

Additional notes

- Golf balls, silicone balls, plastic bottle caps, ceramics, rubber balls, or any other hard object can achieve this finish.
- To reduce abrasion, turn the garment inside out.
- This technique does not yield the same results as a traditional softener bath using a silicone softener; consider the weight of the fabric and desired softness before using this technique.
- A washing machine or a modified dryer can use this technique.

Combine desize, enzyme wash, and bleach

Water savings counted: Two total baths, a desize and an enzyme wash
Average water savings: 11.1 liters / jean
Frequency of use: Low

Traditionally, when bleach follows desize in a finish formula, it requires up to seven baths: a desize bath, a rinse, an enzyme bath, another rinse, a bleach bath, a neutralize bath, and a final rinse. There may be as few as five baths if the rinse between the desize/enzyme and enzyme/bleach steps is omitted. Using specific chemistry allows for a system to achieve the desize/enzyme/bleach all in one bath, which is then followed by a neutralization bath and a rinse. This reduces the process to a total of three baths. Since vendors apply the technique in different ways, we conservatively count the water savings from only two baths, the desize bath and the enzyme wash.

Additional notes

- We recommend running the enzyme wash and desize first and then adding bleach at the end of the step.
- Not recommended for use on a light wash.

Combine desize and stonewash / enzyme wash

Water savings counted: Two total baths, a desize and a rinse
Average water savings: 11.8 liters / jean
Frequency of use: High

When a stonewash or enzyme wash follows a desize bath in a finish formula, it traditionally requires four baths: a desize bath, a rinse, a stonewash or enzyme bath, and another rinse. Combining the desize step with the stonewash/enzyme wash followed by a rinse reduces the process to a total of two baths.

Additional notes

- Not recommended for fabrics that bleed a lot.
- An extra dispersant in the bath may be required to avoid back staining.

Combine resin and tint steps; apply by dipping

Water savings counted: One tint bath
Average water savings: 5.6 liters / jean
Frequency of use: Low

Resin is commonly applied by spray or dipping. Tint is applied in a wet bath and a rinse bath usually follows. By adding tint to the resin solution and applying through spray or dip, the tint wet bath (and sometimes the rinse bath) is removed. Given the variation in rinse baths, we conservatively consider this technique to save the tint bath.

Spray potassium permanganate on raw garments

Water savings counted: One neutralization bath
Average water savings: 5.8 liters / jean
Frequency of use: High

Potassium permanganate spray is typically applied in the middle of a finish formula: after a stonewash, but before the next step. This means the garments are removed from the wet stonewash bath, fully dried, then put on hangers and sprayed with potassium permanganate. The garments then enter a neutralization wet bath and a rinse bath before proceeding to the next step of the finish formula. Applying the spray at the beginning of the finish formula – before the garments ever get wet – allows the neutralization agent to be added to the first existing wet bath. The neutralization bath is removed, and the rinse that follows neutralization is also potentially removed.

Additional notes

- This technique works best with dark finishes
- Be aware of potential back staining.

Neutralize the bleach in the same bath

Water savings counted: One neutralization bath
Average water savings: 5.8 liters / jean
Frequency of use: Low

The bleach bath and neutralization bath are typically separate baths. This technique uses chemistry that can combine the bleach and neutralization baths into a single bath.

Additional notes

- Technique success hinges on the specific neutralizing agent used.
- This technique is not recommended for formulas with potassium permanganate.
- Not recommended for use in high/long-bleach situations.
- A booster may help reduce the length of the bleach cycle.

Low liquor ratio for desize

Water savings counted: ½ desize bath
Average water savings: 2.9 liters / jean
Frequency of use: Low

Typically the desize bath removes any starch or other sizing agents added at a mill. In the past, laundries used high liquor ratios to reduce garment streaking and redeposition of indigo dye. Modern chemistry and modern machine designs allow for lower liquor ratio desize. Levi Strauss & Co. educates laundries to use lower water levels in the desize bath.

Additional notes

- Heavy fabrics may have limited use of this technique.

High fixation reactive dye

Water savings counted: One rinse bath
Average water savings: 5.9 liters / jean
Frequency of use: Low

Traditional reactive dyes have a fixation rate of 55%-65%. The balance of the dyestuff hydrolyzes in the bath before reacting with the fiber, causing deposition of high amounts of inert dyes on the surface of the fiber. This requires additional rinsing and soaping steps to clean the garments of the unfixed dyes. Many modern dyes have a fixation rate of 85%-92%, significantly reducing the redeposition of hydrolyzed dyes on the surface of the fiber which reduces the number of rinsing and soaping steps needed.

Any high fixation reactive dyes on the market are eligible for this Water<Less™ technique once substantiated for actual water savings.

Combine fixing and softener

Water savings counted: One fixation bath
Average water savings: 4.4 liters / jean
Frequency of use: Low

The fixing bath and softener bath are typically separate baths. This technique combines the two. Ensure the fixer and softeners are compatible.

Ozone Mist

Water savings counted: Two total baths, one bleach and one neutralization bath
Average water savings: 12 liters / jean
Frequency of use: Low

Traditional bleaching methods are used to decolorize garments. For the most part, liquor ratios in bleaching baths are high and are followed by a neutralization bath and a rinse step. Ozone mist combines the powerful oxidative potential of ozone with low liquor ratio by spraying a fine mist of water into the machine and onto the garments while ozone is being generated.

Combine enzyme and softener

Water savings counted: Two total baths, one enzyme and one rinse bath
Average water savings: 10.8 liters / jean
Frequency of use: Not yet available for use in bulk at time of reporting

Typically the enzyme bath softens the fabric fibers and a rinse step follows. The softener step further softens the garment. This technique allows for the enzyme and softener steps to be combined.

Additional notes

- Special consideration must be used for enzyme selection to avoid negative impacts on fabric tear strength and restricted substance list concerns.
- Ensure enzymes are neutralized to avoid any long-term fabric degradation.
- Technique works well with non-denim/twill fabrics.

Low liquor ratio bleach

Water savings counted: ½ bleach bath
Average water savings: 3.1 liters / jean
Frequency of use: Not yet available for use in bulk at time of reporting

Traditional bleaching methods are used to decolorize garments. For the most part, liquor ratios used in bleaching baths are high. Modern machine design and technology allow laundries to significantly lower the liquor ratio for the bleach bath.

Low liquor ratio reactive garment dye

Water savings counted: 1 total bath, ½ reactive dye bath and ½ rinse bath
Average water savings: 6 liters / jean
Frequency of use: Not yet available for use in bulk at time of reporting

For the most part, liquor ratios used in reactive dye baths are high and are followed by at least one rinse bath. Levi Strauss & Co. educates laundries to use lower water levels in both the reactive dye bath and the rinse bath that follows.

Enzyme spray stonewash

Water savings counted: One enzyme bath
Average water savings: 4.9 liters / jean
Frequency of use: Low

This technique includes abrasion without water or stones. Instead, an enzyme mixture is sprayed onto garments followed by tumbling the garments in a washing machine with steam. Then a conventional washing process creates the desired aesthetic.

Additional notes

- The aesthetic resulting from this technique may appear more 'flat' than a traditional stonewash.

Key:

	Prohibited: Savings cannot be combined if both techniques appear in the same formula
	Okay: Savings can be combined

Water Saving Duplication Rules

Techniques	Remove desize step	Ozone*	Foam dye/tinting	Foam bleach	Spray softener	Low liquor ratio for stonewash	Sky Bleach / Rags Bleach/ Acid Wash/	Soft rigid	Combine desize, enzyme wash &	Combine desize & stonewash/ enzyme	Combine resin & tint steps & apply by	Spray potassium PP on raw garments	Neutralize the bleach in the same	Low liquor ratio for desize	High fixation reactive dye	Combine fixing & softener	Ozone mist*	Combine enzyme & softener	Low liquor ratio bleach	Low liquor ratio reactive garment	Enzyme spray stonewash
Remove desize step																					
Ozone*																					
Foam dye/tinting																					
Foam bleach																					
Spray softener																					
Low liquor ratio for stonewash																					
Sky Bleach / Rags Bleach/ Acid Wash/ Moonwash																					
Soft rigid																					
Combining desize, enzyme wash & bleach																					
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Water Saving Duplication Rules

Techniques	Remove desize step	Ozone*	Foam dye/tinting	Foam bleach	Spray softener	Low liquor ratio for stonewash	Sky Bleach / Rags Bleach/ Acid Wash/	Soft rigid	Combine desize, enzyme wash &	Combine desize & stonewash/ enzyme	Combine resin & tint steps & apply by	Spray potassium PP on raw garments	Neutralize the bleach in the same	Low liquor ratio for desize	High fixation reactive dye	Combine fixing & softener	Ozone mist*	Combine enzyme & softener	Low liquor ratio bleach	Low liquor ratio reactive garment	Enzyme spray stonewash
Spray PP on raw garments																					
Neutralize the bleach in the same bath																					
Low liquor ratio for desize																					
High fixation reactive dye																					
Combine fixing & softener																					
Ozone mist																					
Combine enzyme & softener																					
Low liquor ratio bleach																					
Low liquor ratio reactive garment dye																					
Enzyme spray stonewash																					

Levi Strauss & Co. Recycle & Reuse (R&R) Program

In 2014, LS&Co. became the first brand in the apparel industry to create a water quality standard for water recycling and reuse. Since 2013, we have been working with innovative supplier partners to implement this program as an initiative under the umbrella of our Water<Less™ program. The R&R standard ensures that both the safety of workers and the quality of our product are not compromised in the reuse and recycling of facility water.

This year, we developed an accompanying manual for our laundry vendors that provides our supplier facilities with guidelines for implementing their own recycled water system, an explanation of the water standard, and the protocol for verifying and re-verifying a facility as qualifying for R&R.

The R&R program enables our laundry vendors to play an even greater role in contributing to the water savings that our company is striving for.

More specifically, our R&R guidelines aim to minimize the vendor's environmental impact of fresh water usage in water-scarce areas by encouraging the reduction of water consumption through reuse. Laundry vendors may find additional benefits to the R&R program, including:

Buffer against increasing water usage regulation by local governments,
Increased availability of clean facility water,
An opportunity to promote sustainable practices as part of a vendor's competitive advantage

The R&R program provides guidelines that outline minimum requirements for the protection of human health and the environment based on global reuse standards

from various countries and the World Health Organization, and guidelines for various allowable facilities reuse applications.

Facility owners are responsible for ensuring the recycled water quality meets all applicable regulatory requirements of the applicable country (federal, provincial, state, local) for the intended use. They are also responsible for the cost to upgrade infrastructure in order to meet these requirements and those for tracking and reporting recycled water usage.

We have successfully launched R&R at two facilities, which has resulted in nearly 34 million liters of water recycled to date. The R&R manual is being distributed to all of our laundry vendors this year and an assessment of each facility will then be conducted so that we can set targets for implementation at additional facilities.

Requirements of R&R

In order to be R&R compliant, a laundry vendor must:

1. Meet the limits of each parameter in the R&R water standard by providing LS&Co. with a semiannual, third-party verified water quality test
2. Use a blend of at least 20% recycled water in its facility processing, landscaping, cooling tower, or plumbing water
3. Provide flow meter data that tracks the amount of recycled water used on LS&Co. products on a seasonal basis
4. Adhere to the safety guidelines as outlined in the R&R manual

The R&R Water Standard

Parameter	Unit	GER	REUSE APPLICATION				Notes
			A	B	C	D	
		Acceptable Parameter Limit	Facility Process (Laundry) Water	Landscape Irrigation (Restricted Access) [1, 2]	Cooling Tower Water [3]	Sanitary Toilet Flushing (Restricted Access) [2]	
pH	pH	6.0-9.0	6.0 - 9.0[a]	6.0 - 9.0[h]	6.0 - 9.0[a]	6.0 - 9.0[a]	Acceptable if within the given range; not acceptable if out of range
Temp.	°C	37.0	N/A	N/A	N/A	N/A	
Total Suspended Solids (TSS)	mg/L	30	10[c]	30[h]	100[b]	30[i]	
Total Dissolved Solids (TDS)	mg/L	NL	2000[c]	1000[f] *	500[b]	NL	* Sensitive plants may require lower TDS, down to 500.
Biochemical Oxygen Demand (BOD5)	mg/L	30	30[a]	30[h]	10[a]	30[i]	Based on a 5-day BOD test
Chemical Oxygen Demand (COD)	mg/L	Test, Monitor and Report	N/A	N/A	N/A	N/A	
Color	color units	Qualitative observation	5 CU or 150 ADMI[j]	NL	NL	40 CU *	* Guideline is based on aesthetics
Total	mg/L as	NL	90[c]	NL	130[b]	NL	

Parameter	Unit	GER	REUSE APPLICATION				Notes
			A	B	C	D	
		Acceptable Parameter Limit	Facility Process (Laundry) Water	Landscape Irrigation (Restricted Access) [1, 2]	Cooling Tower Water [3]	Sanitary Toilet Flushing (Restricted Access) [2]	
Hardness	$CaCO_3$						
Turbidity	NTU	NL	2[a]	NL	NL	NL	Higher turbidity levels may be allowed if they can be shown to correlate to the required TSS levels
Chlorine Residual	mg/L	NL	1[a] - 2[e]	1[h] - 2[f] *	1[a] - 4[e]	1[a] - 4[e]	Acceptable if within the given range; not acceptable if out of range. * Sensitive plants may be damaged at levels as low as 0.5 mg/L.
Iron	mg/L	NL	0.1[c]	5[f]	0.5[b]	0.3 *	* Guideline is based on potential to stain fixtures
Mercury (Hg)	mg/L	0.01	0.01	n/a	n/a	0.015	
Cadmium (Cd)	mg/L	0.01	0.01	n/a	n/a	0.015	
Lead (Pb)	mg/L	0.10	0.10	n/a	n/a	0.15	
Arsenic (As)	mg/L	0.01	0.01	n/a	n/a	0.015	

Parameter	Unit	GER	REUSE APPLICATION				Notes
			A	B	C	D	
		Acceptable Parameter Limit	Facility Process (Laundry) Water	Landscape Irrigation (Restricted Access) [1, 2]	Cooling Tower Water [3]	Sanitary Toilet Flushing (Restricted Access) [2]	
Copper (Cu)	mg/L	0.25	0.25	n/a	n/a	0.375	
Nickel (Ni)	mg/L	0.20	0.20	n/a	n/a	0.30	
Chromium (Cr)	mg/L	0.10	0.10	n/a	n/a	0.15	
Zinc (Zn)	mg/L	1.0	1.0	n/a	n/a	1.50	
Cyanide (CN)	mg/L	0.20	0.20	n/a	n/a	0.30	
Cobalt (Co)	mg/L	0.02	0.02	n/a	n/a	0.03	Applicable to non-denim facilities only
Manganese	mg/L	0.10	0.1[c]	0.2[f]	0.5[b]	0.05 *	* Guideline is based on potential to stain fixtures
Antimony (Sb)	mg/L	0.01	N/A	N/A	N/A	N/A	
Sodium (Na)	mg/L	NL	NL	70[g]	NL	NL	
Chloride	mg/L	NL	NL	100[g] *	500[b]	NL	* Chloride sensitivity varies widely. Consult local agronomists as part of the preliminary design efforts.

Parameter	Unit	GER	REUSE APPLICATION				Notes
			A	B	C	D	
		Acceptable Parameter Limit	Facility Process (Laundry) Water	Landscape Irrigation (Restricted Access) [1, 2]	Cooling Tower Water [3]	Sanitary Toilet Flushing (Restricted Access) [2]	
Fecal Coliform (for combined systems[k])	CFU/ 100 mL	25 CFU/100 mL	75% ND, 25 max[d] *	200 average; 800 max[h] **	75% ND, 25 max[d] *	200 average; 800 max[i] **	* Non-detect for 75% of samples, 25 CFU/100 mL max. ** 200 CFU/100 mL average for year, 800 CFU/100 mL max.
Foam		Not persistent	N/A	N/A	N/A	N/A	

Notes:
[1] If drip irrigation is used, lower water quality limits are recommended for iron and manganese.
[2] Water quality requirements based on RESTRICTED ACCESS. Minimize the potential for human contact with recycled water.
[3] Additional pretreatment may be required due to variability among manufacturer recommendations.
ND = Non-detect, or below detection limit
NL = No limit
[a] Adapted from Suggested Guidelines for Urban Reuse (US EPA)
[b] Adapted from Typical Reclaimed Water Quality Requirements for Cooling Water, makeup for recirculation (Asano, Burton, Leverenz) A lower TSS may be required to comply with the fecal Coliform limits. Higher TDS concentrations may be used but this will reduce potential cycles of concentration and increase precipitation and corrosion problems.
[c] Based on correspondence with LS&Co. process experts (September 2010)
[d] Adapted from State of Florida mandatory reuse standards
[e] Based on USEPA National Primary Drinking Water Standards
[f] Adapted from recommended limits for irrigation (USEPA)
[g] Adapted from Quality of Water for Irrigation (Ayers)
[h] Adapted from Suggested Guidelines for Restricted Access Irrigation (US EPA)
[i] Adapted from Suggested Guidelines for Industrial Reuse (US EPA)
[j] Adapted from Typical Reclaimed Water Quality Requirements for Textiles (Asano, Burton, Leverenz)
[k] Combined systems contain domestic wastewater, in addition to industrial (process) wastewater.

For full references, see Appendix A of R&R Manual

An Overview of the R&R Process