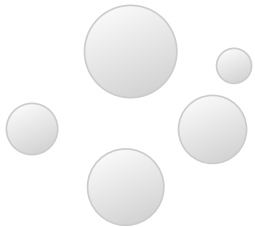




Version 7
Suite Compatible

hyd-RO-doseTM
reverse osmosis



hyd-RO-dose User Manual

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hyd-RO-dosetm

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Selecting Analytical Units

Choosing the pH Control Point

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"What-if" Modeling

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WHY USE hyd-RO-dose?

hyd-RO-dose allows a water treatment chemist to evaluate the scale potential for common scalants over the range of water chemistry, temperature, pressure, pH and recovery anticipated in membrane system. . hyd-RO-dose can evaluate the scale potential over a broad range of recovery and pH control options.

hyd-RO-dose was developed to allow a water treater to readily evaluate the scale potential for common scalants over the broadest of parameter ranges without the necessity for tedious manual calculations for the Stiff-Davis, , Langelier saturation index, Ryznar stability index, or other indices. Even when all of these common indices are available conflicting results can cloud interpretation of what they are foretelling. These indices are also limited to calcium carbonate scale prediction. hyd-RO-dose allows a water treater to review popular and some less known indicators relatively painlessly to develop a more complete picture of problems, and potential problems anticipated from a water.

hyd-RO-dose also provides "portable" indices in the form of saturation levels. The saturation levels calculated by the program account for "common ion effects" through a procedure called speciation or ion pairing. This method allows indices to be based upon free ions present rather than total analytical values to provide meaningful common denominators for comparing the scale potential of vastly different water chemistries on as close to an apples basis as possible. The use of ion pairing also allows calculations at very high ionic strength where the association of ions become as important, or more important, than the method used to estimate activity coefficients.

In summary, hyd-RO-dose is used to:

- To develop an overall profile of scale potential for common scalants over the entire range of critical parameters anticipated.
- To evaluate the impact of acid feed on scale potential and scale inhibitor requirements.
- To evaluate the impact of % recovery on acid and/or inhibitor requirements.
- To quickly review these indicators as water quality changes, or environmental constraints force operation with reduced water quality and increased scale potential.
- To learn more about the interaction of water chemistry and operating conditions (pH, temperature, recovery, pressure) by using the program as a system simulator.
- To save time. hyd-RO-dose can calculate and save the indices you currently calculate by hand, and store the water analyses and calculated indices. In many cases, hyd-RO-dose allows you to prepare presentation quality graphical profiles in about the same time it would take to manually calculate the Langelier and Stiff-Davis indices. hyd-RO-dose provides a complete profile for the manpower cost of calculating a few indices using a nomograph or water chemistry slide rule.

WHAT hyd-RO-dose WON'T DO!

hyd-RO-dose will not recommend a treatment program. It will not substitute for experience. You will have to provide the interpretation based upon your, and your company's, knowledge of inhibitor effective limits.

hyd-RO-dose programs will provide guidelines for treatment levels, and where inhibitor limitations are known, warn you of projected inhibitor failure through color coding. Dosages turn RED when out of range.

WHAT INDICATORS DOES hyd-RO-dose CALCULATE?

hyd-RO-dose calculates indicators of scale potential for barium sulfate (barite), barium carbonate, (witherite) calcium carbonate, calcium sulfate (anhydrite and gypsum), strontium sulfate (celestite), calcium phosphate (hydroxyapatite and tricalcium phosphate), amorphous iron hydroxide, iron phosphate(strengite), iron carbonate (siderite), amorphous silica, calcium fluoride (fluorite), and magnesium hydroxide (brucite). It also calculates common, simple indices for reference. Simple indices calculated over the range of conditions specified include:

- the most common (Stiff-Davis, Langelier and Ryznar);
- those that have been used by the major water treatment companies but have generally been unavailable to most water treaters (Saturation levels based upon an ion association model);
- and some that the program author has found useful (the Larson-Skold corrosivity index).

A detailed review of these indices is included in a later section of this manual, and in references in the bibliography. hyd-RO-dose calculates indicators of scale potential for calcium carbonate, tricalcium phosphate, hydroxylapatite, silica, calcium sulfate, calcium fluoride, magnesium hydroxide, magnesium silicate, iron hydroxide, iron carbonate, and iron phosphate. It also calculates a corrosivity index based upon the work of Drs. Larson and Skold on the corrosivity of Great Lakes waters towards mild steel.

SIMPLE INDICES

The Langelier Saturation Index

The Langelier Saturation index (LSI) is a purely equilibrium model derived from the theoretical concept of saturation. A water is said to be saturated with calcium carbonate when it will neither dissolve, or precipitate calcium carbonate "scale". This equilibrium

condition is based upon an undisturbed water, at constant temperature, which is allowed to remain undisturbed for an infinite period of time. A water is said to be under-saturated if it will dissolve an existing calcium carbonate substrate if left at rest for the same infinity. A supersaturated water will precipitate calcium and carbonate from a water if allowed to rest. The Langelier saturation index provides an indicator of a water's degree of saturation with respect to calcium carbonate.

Saturation is referenced to the solubility product for a compound. By definition the ion activity product of reactants (e.g. Ca and CO₃) is equal to the solubility product (K_{sp}) when the water is in equilibrium.

$$[\text{Ca}]\alpha_{\text{Ca}}[\text{CO}_3]\alpha_{\text{CO}_3} = K_{\text{sp}}$$

A saturation level is defined as the ratio of the ion activity product to the solubility product.

$$\text{Saturation level} = \frac{\alpha_{\text{Ca}}[\text{Ca}]\alpha_{\text{CO}_3}[\text{CO}_3]}{K_{\text{sp}}}$$

If a water is under-saturated with respect to calcium carbonate, the saturation level will be less than 1.0 . When a water is at equilibrium, the saturation level will be 1.0 by definition (although our estimation of the ion activity product or solubility product might be in error). A water which is supersaturated with calcium carbonate will have a saturation level greater than 1.0 .

Saturation level is the driving force for crystal formation, and crystal growth. As the saturation level increases beyond 1.0, the driving force for calcium carbonate crystal formation or crystal growth increases.

It can be shown that the Langelier saturation index approximates the base 10 logarithm of calcite saturation level. The Langelier saturation level approaches the concept of saturation using pH as a master variable(1). The Langelier saturation index can be interpreted as the pH change required to bring a water to equilibrium. A water with a Langelier saturation index of 1.0 is one pH unit above saturation. Reducing the pH by 1 unit will bring the water into equilibrium. This occurs because the portion of total alkalinity present as CO₃ (the bad actor) decreases as the pH decreases. A pH decrease of 1 unit will decrease the CO₃ concentration of the water about ten fold. This impacts saturation level directly by also decreasing the ion activity product tenfold. So a 1 pH unit decrease will decrease the Langelier saturation index by 1 unit. A 1 pH unit decrease will also decrease the saturation level (IAP/K_{sp}) ten fold.

A negative Langelier saturation index indicates that a water is under-saturated with respect to calcium carbonate (calcite). If the LSI is -1.0, raising the pH of the water 1 unit will increase the calcium carbonate (calcite) saturation level to equilibrium. The 1 pH unit increase does this by increasing the CO₃ portion of the carbonate alkalinity present ten fold. The calcite saturation level increases accordingly (ten times).

The Langelier saturation index is probably the most widely used indicator of cooling water scale potential. It is purely an equilibrium index and deals only with the driving force for calcium carbonate scale formation and growth. It provides no indication of how much scale (CaCO_3) will precipitate to bring a water to equilibrium. It simply indicates the driving force for scale formation and growth in terms of pH as a master variable.

The Langelier saturation index is defined as:

Langelier saturation index = pH - pH_s

- pH is the measured water pH
- pH_s is the pH where the water will be saturated (at equilibrium) with respect to CaCO_3 .

In the cooling water pH range of 6.5 to 9.5, the pH_s calculation simplifies to:

$$\text{pH}_s = (\text{pK}_2 - \text{pK}_s) + \text{pCa} + \text{pAlk}$$

- pK₂ is the negative log₁₀ of the second dissociation constant for carbonic acid;
- pK_s is the negative log₁₀ of the solubility product for calcite;
- pCa is the negative log₁₀ of calcium measured in the water;
- pAlk is the negative log₁₀ of the total alkalinity measured for the water being evaluated.

hyd-RO-dose uses the full iterative method for estimating the pH of saturation for calcite for calculating the Langelier saturation index.

The LSI is analogous to voltage for those who are electrically minded. A voltage is the driving force for moving electrons across a resistance. As voltage potential difference increases, there is a higher driving force for current (electron) flow. Voltage, however, indicates nothing of the current being moved. The LSI, and other saturation level based indices, describe the driving force for scale formation and growth, but say little of the amount of scale which will form (or be dissolved) in order to bring a water to equilibrium. Although they are very useful, a second factor must be considered in interpreting saturation level based indices. Saturation level based indices indicate the potential for scale formation if a water is unperturbed for an infinite period of time. Most cooling water systems have a substantially shorter holding time index.

A final point on the Langelier index deals with the concept of "corrosivity." The LSI was not intended as an indicator of corrosivity towards mild steel or other metals of construction. The LSI describes only the corrosivity of a water towards an existing calcium carbonate scale, or other calcium carbonate bearing structure. The LSI does describe the tendency of a water to dissolve (corrode) calcite scale. It has also been used to control the "corrosion" of asbestos-concrete-board (ACB) fill which uses calcium carbonate as part of the binder. Water is

LSI. But the interpretation of corrosivity towards metals is not explicit in the LSI.

It has been postulated that a supersaturated water will form an eggshell like film of calcium carbonate scale which will act as an inhibitor film for corrosion of mild steel. This can occur in highly buffered waters. The LSI or other saturation based indices do not guarantee this inhibitory behavior. Calcium carbonate film formation is typically observed in highly buffered waters.

Researchers (Stumm(3), Lowenthal, and Marais(4)) have shown that waters supersaturated with calcium carbonate often develop tubercular deposit which do not inhibit corrosion on mild steel.

This behavior is typically associated with waters of low buffer capacity. Puckorius(5) also warned against using saturation level derived indices as the basis for foretelling corrosion problems in systems.

The Langelier saturation index is elegantly derived in the original published form(2). It is also thoroughly explained by Lowenthal and Marais(4).

The Ryznar Stability Index

The Ryznar stability index attempts to correlate an empirical data base of scale thickness observed in municipal water systems to the water chemistry. Like the Langelier saturation index, the Ryznar stability index has its basis in the concept of saturation level. Ryznar attempted to quantify the relationship between calcium carbonate saturation state and scale formation. The Ryznar index takes the form:

$$\text{Ryznar stability index} = 2(\text{pH}_s) - \text{pH}$$

The empirical correlation of the Ryznar stability index can be summarized as follows:

- RSI << 6** scale tendency increases as the index decreases;
- RSI >> 7** calcium carbonate formation will probably not lead to a protective corrosion inhibitor film;
- RSI >> 8** mild steel corrosion becomes an increasing problem.

hyd-RO-dose uses the pH_s calculated by the rigorous iterative method for RSI estimation.

The Stiff-Davis Saturation Index

The Stiff-Davis index attempts to overcome the shortcomings of the Langelier Index with respect to high TDS waters and the impact of "common ion" effects on the driving force for scale formation. Like the Langelier saturation index, the Stiff-Davis index has its basis in the concept of saturation level. The solubility product used to predict the pH of saturation (pH_s) for a water is empirically modified in the Stiff-Davis index. Stiff-Davis indices will predict that a water is less scale forming than the Langelier index calculated for the same water chemistry and conditions. The deviation between the indices increases with ionic strength. Interpretation of the index is by the same scale as for the Langelier Saturation index.

The Practical (Puckorius) Scaling Index

The Puckorius (or Practical) scaling index attempts to further quantify the relationship between saturation state and scale formation by incorporating an estimate of buffering capacity of the water into the index. The previously discussed saturation derived indices only account for the driving force for calcium carbonate scale formation. They do not account for two other critical parameters: the buffering capacity of the water, and the maximum quantity of precipitate that can form in bringing a water to equilibrium.

A water high in calcium, but low in alkalinity and buffering capacity can have a high calcite saturation level. The high calcium level increases the ion activity product. A plot of ion activity product versus precipitate for the water would show a rapid decrease in pH as calcium precipitated due to the low buffering capacity. Even minuscule decreases in carbonate concentration in the water would drastically decrease the ion activity product of the water due to the small quantity present prior to the initiation of precipitation. The water might have a high tendency to form scale due to the driving force, but scale formed might be of such a small quantity as to be unobservable. The water has the driving force but no capacity and no ability to maintain pH as precipitate forms.

The Puckorius scaling index is calculated in a manner similar to the Ryznar stability index. Puckorius uses an equilibrium pH rather than the actual system pH to account for the buffering effects:

$$\text{Puckorius scaling index} = 2 (\text{pH}_{\text{eq}}) - \text{pH}_s$$

hyd-RO-dose calculates the pH_s for this index using the rigorous iterative method. Puckorius' formula for pH_{eq}(5) is used

$$\text{pH}_{\text{eq}} = 1.465 \times \log_{10}(\text{"M" Alkalinity}) + 4.54$$

The Puckorius scaling index provides another tool for evaluating the calcium carbonate scale potential for a water and is included in the hyd-RO-dose indices of calcium carbonate scale potential.

The Larson-Skold Corrosivity Index

The Larson-Skold index describes the corrosivity of water towards mild steel. The index is based upon evaluation of in-situ corrosion of mild steel transport lines in systems transporting Great Lakes waters. The index is the ratio of equivalents per million (epm) of sulfate (SO₄) and chloride (Cl) to the equivalents per million of alkalinity in the form bicarbonate plus carbonate (HCO₃ + CO₃).

$$\text{Larson-Skold index} = \frac{(\text{epm Cl} + \text{epm SO}_4)}{(\text{epm HCO}_3 + \text{epm CO}_3)}$$

As outlined in their paper (6), the index correlated closely to observed corrosion rates and to the type of attack in the Great Lakes water study.

It should be noted that the waters studied in the development of the relationship were not alkalinity or buffering capacity deficient. They were capable of forming an inhibitory calcium carbonate film, if no interferences were present.

The results of the study demonstrate that chlorides and sulfates increase the aggressiveness of a cooling water with adequate buffering capacity and alkalinity to otherwise not be overly aggressive. Perhaps the presence of chloride and sulfate interferes with the film formation which otherwise would be expected.

It must be noted that the Larson-Skold relationship is based upon Great Lakes waters. Extrapolation to other waters, such as those of low alkalinity or extreme alkalinity, goes beyond the range of the original data. Such extrapolations should be closely scrutinized or weighted lightly. Most water treaters will agree, however, that the aggressiveness of a water increases with increasing chloride and/or sulfate levels, and that corrosivity also increases with decreasing alkalinity.

The index has proven a useful tool in predicting the aggressiveness of once through cooling waters. It is included in hyd-RO-dose due to the preponderance of waters of composition similar to the Great Lakes waters, and due to its potential usefulness as an indicator of aggressiveness in reviewing the applicability of corrosion inhibition treatment programs which rely heavily on the natural alkalinity and film forming capabilities of a cooling water.

The index might be interpreted by the following guidelines:

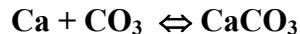
Larson-Skold	Indication
<< 0.2	chlorides and sulfate probably will not interfere with natural film formation.
>> 0.2 but << 0.8	chlorides and sulfates may interfere with natural film formation. Higher than desired corrosion rates might be anticipated.
>> 0.8	the tendency towards high corrosion rates of a local type should be expected as the index increases.

MORE INVOLVED CALCULATIONS

Ion Association Model Saturation Level

Saturation level has been previously discussed as the basis for many of the common indices used by water treaters. The saturation level is defined as the ratio of the ion activity product of the reactants to the solubility product. Saturation level can be defined as follows for common system scalants based upon their respective solubility products:

For CaCO₃ (calcite and aragonite)



$$\text{Saturation Level} = \frac{[\text{Ca}] \alpha_{\text{Ca}} [\text{CO}_3] \alpha_{\text{CO}_3}}{K_{\text{sp}}}$$

where α_{Ca} is the activity coefficient for calcium
 α_{CO_3} is the activity coefficient for carbonate
 $[\text{Ca}]$ is the molar concentration of calcium
 $[\text{CO}_3]$ is the molar carbonate concentration

This relationship can be simplified if we incorporate the activity coefficients into the solubility product so that our examples can be expressed in a more readily viewed format. The conditional solubility product incorporates the activity coefficients into the solubility product:

$$K_{\text{sp}_c} \text{CaCO}_3 = K_{\text{sp}} \times (1/\alpha_{\text{Ca}}) \times (1/\alpha_{\text{CO}_3})$$

This notation (K_{sp_c}) will be used for the remainder of the examples.

For Calcium sulfate (anhydrite):



$$\text{Saturation level}_{(\text{CaSO}_4)} = \frac{[\text{Ca}][\text{SO}_4]}{\mathbf{Ksp}_c(\text{CaSO}_4)}$$

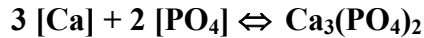
For Silica



$$\text{Saturation level}(\text{SiO}_2) = \frac{\text{H}_4\text{SiO}_4}{([\text{H}_2\text{O}][\text{H}_2\text{O}] \mathbf{Ksp}_c)}$$

Note that the activity of water is included in the calculation.

For tricalcium phosphate, a higher order of reaction is encountered:



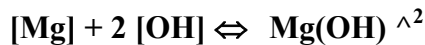
$$\text{Saturation level} = \frac{[\text{Ca}]^3[\text{PO}_4]^2}{\mathbf{Ksp}_c}$$

A higher order of reaction is also encountered for calcium fluoride (Fluorite)



$$\text{Saturation level} = \frac{[\text{Ca}][\text{F}]^2}{\mathbf{Ksp}_c}$$

and magnesium hydroxide (Brucite):



$$\text{Saturation level} = \frac{[\text{Mg}][\text{OH}]^2}{\mathbf{Ksp}_c}$$

The method used for estimating activity coefficients is a major target of criticism for most indices. hyd-RO-dose uses the mean salt activities for estimating ion activity coefficients based upon temperature and ionic strength. The method is well covered in reference Truesdell and Jones(7). The use of ion pairing expands the usefulness of hyd-RO-dose calculated saturation levels.

The simple indices previously described are based upon saturation levels calculated using the total ions present. For example, calcium carbonate indices, such as the Langelier saturation index, assume that all calcium is present as free calcium ions, and that all carbonate is present as the unbound ion. In actual waters, the reactive species are present in many forms. Not all of the ion measured analytically is available to react. For example, calcium can be bound with hydroxide, sulfate, carbonate, and bicarbonate and unavailable for other reactions. This binding, or reduced availability of the reactants, decreases the effective ion activity product for a saturation level calculation. hyd-RO-dose uses an ion association model to estimate the available (or free) ions present in the water. The ion association method is well described in the literature.⁽⁷⁾⁽⁸⁾⁽⁹⁾⁽¹⁰⁾⁽¹¹⁾ hyd-RO-dose uses the free ion concentrations estimated by the ion association method in saturation level calculations. The resultant saturation levels calculated are significantly lower than those based upon total analytical values.

The ion association model saturation levels have been in use by the major water treatment companies since the early 70's. The indices tend to give a more accurate indication of the driving force for scale formation. They have not been in general use, however, due to the difficulty of calculating them. The iterative approach required for the calculations mandates the use of a computer. One of the purposes of hyd-RO-dose is to make the ion association method for saturation levels available to all Water Treaters.

Saturation levels, no matter how refined, are still an equilibrium based index. They provide a measure of the driving force for a scalant to form, but do not incorporate the capacity of the water for continued scaling. A water can have a high saturation level with no visible scale formation. The driving force might be present but there is insufficient mass for gross precipitation.

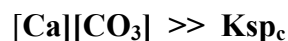
Saturation levels should be viewed as another tool for developing an overall picture of a water's scale potential. They can point out what scales won't form under the conditions evaluated, but they can not predict that deposits of an economically significant quantity will form. The next index covered incorporated the properties of quantity as well as driving force to round out the hyd-RO-dose indicators of scale potential.

Momentary Excess (Precipitation To Equilibrium)

This index is adapted from a little used calculation of Momentary Excess. This index describes the quantity of scalant which would have to precipitate instantaneously to bring a water to equilibrium. In the case of calcium carbonate:



If a water is supersaturated:



Precipitation to equilibrium assumes that one (1) mole of calcium will precipitate for every mole of carbonate that precipitates. On this basis, we can estimate a quantity X, the precipitation required to restore a water to equilibrium, as follows:

$$[\text{Ca} - \text{X}][\text{CO}_3 - \text{X}] = \text{Ksp}_c$$

X is a quantitative indicator of precipitation reserve for a water. X will be a small value when either calcium is high and carbonate low, or when carbonate is high and calcium low. It will increase to a maximum when equal parts of calcium and carbonate are present. As a result, this index (Precipitation to Equilibrium) will provide vastly different values for waters with the same saturation level. Although the original Momentary Excess index was applied only to calcium carbonate scale, hyd-RO-dose extends the index to other scale forming species.

In the case of sulfate, momentary excess is calculated by solving for "X" in the relationship:

$$[\text{Ca} - \text{X}][\text{SO}_4 - \text{X}] = \text{Ksp}_c$$

The solution becomes more complex for tricalcium phosphate:

$$[\text{Ca} - 3\text{X}]^3 [\text{PO}_4 - 2\text{X}]^2 = \text{Ksp}_c$$

The index provides a quantitative indicator of scale potential and has been used to correlate scale formation in a kinetic model(12). The index does not account for two critical factors. The pH will change in some cases as precipitate forms by the precipitation of alkalinity contributors such as carbonate or phosphate. Secondly, the index does not account for changes in driving force as the reactant levels decrease due to precipitation.

hyd-RO-dose includes Momentary Excess (precipitation to equilibrium) as a final indicator of scale potential for the scalants covered by the computer program. hyd-RO-dose expresses the precipitation to equilibrium in parts per million.

Momentary Excess does not represent a quantitative assessment of the amount of a fouling which will precipitate. It is an indicator of the capacity of a water to scale, and can be compared to the buffer capacity of a water. The calculation method is covered in more detail in the literature(12).

INTERPRETING hyd-RO-dose INDICES

Scale Potential As Indicated By Saturation Level

All but one of the indices discussed in this section describe the tendency of a water to form, or dissolve, a particular scale. These indices are derived from the concept of saturation. For example, saturation level for any of the scalants discussed is described as the ratio of a compounds observed ion activity product (**IAP**) to the ion activity product expected if the water were at equilibrium (**Ksp**). In hyd-RO-dose graphically profiles, the degree of supersaturation is labeled as this ratio (**IAP/Ksp**). This ratio has many names and is referred to as *Saturation Level*, *Degree of supersaturation*, and *x Saturation*. This ratio will be referred to as *Saturation Level* or *Degree of supersaturation* throughout the manual.

The following general guidelines can be applied to interpreting the degree of supersaturation:

- 1) If the saturation level is less than 1.0, a water is under saturated with respect to the scalant under study. The water will tend to dissolve, rather than form, scale of the type for which the index was calculated. As the saturation level decreases and approaches 0.0, the probability of forming this scale in a finite period of time also approaches 0.
- 2) A water in contact with a solid form of the scale will tend to dissolve or precipitate the compound until an IAP/Ksp ratio of 1.0 is achieved. This will occur if the water is left undisturbed for an infinite period of time under the same conditions. A water with a saturation level of 1.0 is at equilibrium with the solid phase. It will not tend to dissolve, or precipitate the scale.
- 3) As the saturation level (IAP/Ksp) increases above 1.0, the tendency to precipitate the compound increases. Most waters can carry a moderate level of supersaturation before precipitation occurs in a finite period of time - such as the seconds to minutes a water is present in a once through system, or the hours to days a water is present in a cooling tower system. Most systems can carry a small degree of supersaturation. The degree of supersaturation acceptable for a system varies with parameters such as residence time, the order of the scale reaction, and the amount of solid phase (scale) present in the system. To be on the safe side, it is recommended that an appropriate inhibitor be fed to a system if the saturation level is above 1.0.

The acceptable degree of saturation for a given system should be based upon your experience. The author has found the following guidelines useful.

Calcium carbonate: In once through systems, treatment is necessary when the saturation level at the highest temperature and pH in the system is above 1.2 to 1.5.

A slightly higher degree of supersaturation can be carried in some cooling towers.

Calcium sulfate: Treatment is recommended when the saturation level for gypsum exceeds 1.0. In higher temperature systems (>> 130 °F), treatment is required normally when anhydrite saturation level exceeds 1.0.

Silica: Most cooling waters can carry a silica saturation level of 1.1 to 1.2. hyd-RO-dose silica saturation levels are calculated using the solubility product for amorphous silica. A saturation level in this range equates to a cooling water silica level of around 150 ppm (as SiO₂) at an acid to neutral pH, and 180 ppm or above in waters with a pH above 8.0. This is comparable to the old guidelines for "acid chromate programs" (150 ppm as SiO₂) used by most water treatment companies when such treatments were acceptable, and for the guidelines for the new "All Organic" programs (180 to 200 ppm) operating in the pH range of 8.0 to 9.0+.

It is of particular importance to evaluate silica saturation level in systems with borderline solubility as cooling water temperature or pH decrease seasonally.

Magnesium silicate: Mag-silicate compounds do not necessarily form due to a stoichiometric reaction. The author believes that magnesium silicate forms through the adsorption of silica onto precipitated magnesium hydroxide. Brucite saturation level was added to hyd-RO-dose calculated indices as a measure of the potential for magnesium silicate to form in a system based upon this philosophy. If a water is supersaturated with magnesium hydroxide (Brucite) and even low levels of reactive silica are present in the cooling water, magnesium silicate formation is possible. Magnesium silicate formation is probable when the water is supersaturated with Brucite and silica levels are 40 ppm (as SiO₂) or above.

A recent NACE paper reported the formation of stoichiometric magnesium silicate scales in systems. A stoichiometric form was added to the scales evaluated by hyd-RO-dose as a result of this paper. Precipitation might be expected when the magnesium silicate saturation level exceeds 1.2.

Calcium fluoride: Treatment, or operating parameter changes, are recommended when the saturation level for Fluorite exceeds 1.0.

Tricalcium phosphate: Tricalcium phosphate saturation level calculations are a fifth order affair. As a consequence, small changes in free phosphate concentration, or even smaller changes in calcium concentration, have a dramatic impact on the calculated saturation level. For this reason, high saturation levels, on the order of 100,000 or above, can be observed in cooling waters treated for calcium phosphate scale control. The authors experience is as follows:

Beware when a system is supersaturated with tricalcium phosphate.

A tricalcium phosphate saturation level below 100 is easily treated. Most inhibitor treatments can prevent scale formation, even if not specifically directed towards tricalcium phosphate. pH decrease can decrease tricalcium phosphate saturation level to an acceptable level.

pH reduction and/or a tricalcium phosphate specific treatment program is recommended when tricalcium phosphate saturation level rises above the 100 to 1000 range.

hydroxylapatite: Hydroxylapatite saturation level calculations are a ninth order affair even higher than that of tricalcium phosphate. As a consequence, small changes in free phosphate concentration, or even smaller changes in calcium concentration, have a dramatic impact on the calculated saturation level. For this reason, high saturation levels, on the order of 100,000 or above, can be observed in cooling waters treated for calcium phosphate scale control. Saturation level guidelines are similar to those for tricalcium phosphate, although a significantly higher hydroxylapatite saturation level can be carried in the presence of a copolymer, terpolymer, or other calcium phosphate scale control agents.

Iron carbonate: Siderite, the mineral name for iron carbonate, is usually found in conjunction with calcium carbonate scale in system. Iron carbonate scale can be expected when the saturation level exceeds 1.2 .

Amorphous iron hydroxide: Iron hydroxide precipitation can be expected in cooling water when the saturation level exceeds 1.0, a very common situation when iron is present. Iron may precipitate in the bulk water as iron hydroxide, but not form scale in high flow rate systems. Remedial action, such as a dispersant, should be taken in systems with high iron hydroxide saturation levels. Note that iron hydroxide momentary excess values reported will almost always be negligible. This is due to the high order of the reaction. Rely upon the saturation level for deposition prediction and ignore the momentary excess in most cases.

Iron phosphate: Strengite, the iron phosphate mineral modeled by hyd-RO-dose, should be considered a problem when the saturation level exceeds 1.0 . Momentary excess for this scale former will be negligible in most cases due to the low level of "free" phosphate typically available. Rely upon the saturation level for prediction of iron phosphate scale.

CaCO₃ Scale & Corrosion Potential As Inferred From Simple Indices

The Langelier Saturation Index, Stiff-Davis, Ryznar Stability Index, and Puckorius (or Predictive) Scaling Index are well documented. Values calculated by hyd-RO-dose for these indices should be very close to those calculated using normal methods. Guidelines for these indices are covered in their respective sections of this manual. It should be noted that these indices are limited to calcium carbonate scale potential. They are based upon total calcium and total alkalinity present and may be of limited usefulness in high TDS waters for this reason. The indices, as previously discussed, do not account for ion pairing which reduces the free calcium and carbonate concentrations available for scale formation. It is recommended that these indices be used as points of reference and that the more rigorous saturation level for calcite be adopted, especially in high TDS waters.

hyd-RO-dose COLOR CODING

Graphs produced by hyd-RO-dose are color coded as an aid in interpreting them. This section discusses the meaning of the colors.

Saturation Level and Simple Scale Indices

RED - Red signifies a definite problem prediction. Corrective action such as treatment, pH adjustment, or concentration ratio decrease (blowdown) should be taken to eliminate, or alleviate, the problem. Red signifies loss of control in TREATED SATURATION LEVEL PROFILES.

MAGENTA - Magenta (purple) signifies that a problem is highly likely. Some systems might be able to carry the degree of supersaturation indicated by magenta without deposition occurring. Most system will scale if operated in the Magenta range without treatment.

YELLOW - Yellow signifies that a problem will occur with a minimum of change. Make sure of your measurements. A slight error in pH could mean that you are really operating in a RED zone. The system is borderline and should be watched.

GREEN - No problems are likely. Significant changes (e.g. a 0.1 pH increase, a 10 °C increase) could result in a problem.

BLUE - Blue signifies a safe operating range where deposition from the scale evaluated would not be expected. Blue is also used to signify a successful treatment in TREATED SYSTEM PROFILES.

Dosage Profiles

RED - Red signifies a definite problem prediction. The treatment will not work regardless of dosage level. The system is out of range (e.g. too high a saturation level) for the treatment selected.

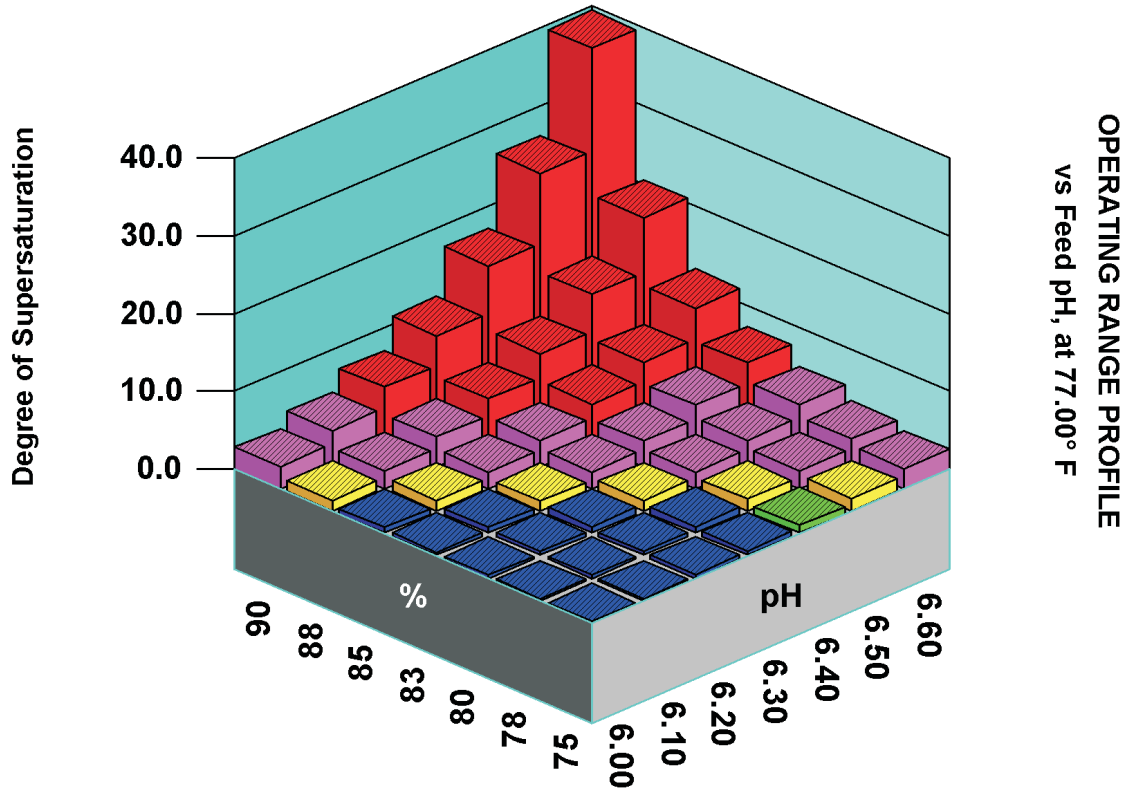
MAGENTA - Magenta (purple) signifies that a problem is approaching or highly likely. In the case of calcium carbonate inhibitors, MAGENTA signifies that the system is within ten (10%) percent of the limit for the inhibitor (e.g. 135 calcite saturation level to 149 calcite saturation level for an inhibitor that fails at 150 or above).

In the case of blended orthophosphate/copolymer products, MAGENTA signifies that insufficient polymer is present for calcium phosphate scale control when the product is dosed at the level required for adequate corrosion protection. The corrective action is to increase the ratio of copolymer to phosphate.

BLUE - Blue signifies a safe operating range where the treatment will prevent deposition of the scale evaluated.

"Fuzzy Chemistry"tm Profiles Predict Problems Over A Broad Range of Operating Conditions

Calcite



Color coding identifies the severity of the problem.

Blue signifies a safe range.

Green indicates a mild problem
potential if conditions change slightly.

Yellow warns you to check measurements, trouble is near.

Magenta indicates a problem is likely. Take corrective action.

Red warns of a problem. Treatment or
other remedial action is required.

THE hyd-RO-dose R_x SERIES

hyd-RO-dose R_x Series Programs

The Field Engineer Edition
The Formulator Edition
The Laboratory Edition

hyd-RO-dose Files

Workspace Files (.HYD)
Membrane Specification Files (.MBR)
Graphic Files (.PCX, .TIF, .BMP)
Data Output Files (.DAT)
Product Files (.PRD)
Inhibitor Files (.INH)

hyd-RO-dose Rx Series Programs

Most of us use our own system for varying inhibitor treatment levels with water chemistry. Over the years we've developed our own rules of thumb. For example,

- Most of us apply higher levels of inhibitors as temperature increases.
- Most of us increase dosage as the driving force for scale formation increases. Higher levels of CaCO₃ inhibitors are applied as the Langelier Saturation index or calcite saturation level increase.
- Many of us will feed higher inhibitor levels to a 72 hour holding time index system than to a 3 hour residence time system. We will definitely feed higher levels to a long holding time system than to a short residence time system.
- And finally, most of us will feed a slightly higher dosage in high pH systems.

All other things being equal, dosages for scale inhibitors are applied as a function of a driving force for scale formation and growth (e.g. Calcite saturation level), temperature as it affects reaction rates, pH as it affects the dissociation state of the inhibitor, and time. hyd-RO-dose Rx allows you to develop mathematical models for the minimum effective scale inhibitor dosage as a function of these parameters: driving force, temperature, pH and time. Mathematical models for inhibitors can be developed using the Laboratory version of hyd-RO-dose by editing water chemistry, temperature, and time data developed in the laboratory, through field experience, or both.

The hyd-RO-dose Rx series is composed of the following programs:

- **hyd-RO-dose Rx Field Engineer's Edition** - This version of the program allows a user to select a product and obtain a dosage or dosage profile. Product (.PRD) files must be supplied for each product the Field Engineer's version can model. The program can also perform all functions of the basic hyd-RO-dose program. Dosage recommendations are incorporated into the basic hyd-RO-dose system as an additional line of output on the tables output, and as an additional graph selection in the "What-if" modules.
- **hyd-RO-dose Rx Formulator's Edition** - This version allows a user to input a product formulation and create a Product (.PRD) file. The program must have access to Inhibitor(.INH) files for an inhibitor to be incorporated into a formulation. The Formulator's version incorporates all functions and printouts available in the basic hyd-RO-dose program, and in the Field Engineer's Edition of the hyd-RO-dose Rx series.
- **hyd-RO-dose Rx Laboratory Edition** - This version allows a user to develop mathematical models for scale and corrosion inhibitors, in addition to the functions of the other programs in the series. Mathematical model templates are available for common inhibitors types. Laboratory and/or field data can be entered in forms almost identical to the regular hyd-RO-dose chemistry input forms.

Additional fields in the Laboratory version are time and dosage. Mathematical models for an inhibitor are developed by the program using multiple regression. The correlations (models) developed are output in the form of inhibitor (.INH) files. The goodness of fit for the data can be presented in table and graphical format.

The hyd-RO-dose Rx Laboratory and Formulator's Editions are shipped with inhibitor files for common materials such as AMP, HEDP, PBTC, and PAA to name a basic few. Inhibitor files are also available for calcium sulfate control agents, calcium phosphate control, corrosion inhibitors, and modeling corrosion rates on mild steel. Additional files are available from inhibitor's manufacturers.

The hyd-RO-dose Rx Laboratory Edition includes the raw data for AA-AMPS as published by Calgon in a NACE paper.

Correlations can be developed for dosages versus any of the hyd-RO-dose indices, any of the data input, and some internal calculated values such as buffer capacity..

DIFFERENCES BETWEEN hyd-RO-sat and the hyd-RO-dose R_x Series

The hyd-RO-dose R_x series adds one or two pull down menus to the main hyd-RO-dose menu.

The Field Engineer's Edition has one selection on the additional menu (FORMULARY) and one additional selection - SELECT PRODUCT. This module displays a list of the products on file, and their description. The Product Names and Descriptions listed are derived from the Product(.PRD) files. Printouts contain one additional line for the recommended dosage for the current product selected. An additional graph selection is available for Product dosage profiles. Although the Field Engineer's Edition of the program allows the use of the mathematical models and formulation data in the product file, the original data cannot be accessed. Someone with a product file cannot determine the active ingredients or their percentage in the formulated product.

The Formulator's Edition adds a second additional selection to the FORMULARY menu - INPUT PRODUCT. The product's name, description, and formulation are entered in this menu to create a Product (.PRD) file. Only inhibitors for which you have Inhibitor (.INH) files can be included in the formulations.

The Laboratory Edition adds a second additional pull down menu, which is appropriately labeled - LABORATORY. Water chemistry data, dosage, temperature, and the time period during which the water was "stable" are entered into the RAW DATA INPUT module. Once data is entered, multiple regression is used to develop a model and determine the goodness of fit between your data, and the model. This module generates Inhibitor files for use by the Formulator version of the program, or the related modules in the Laboratory version. Note: the Laboratory version can perform any function done by the Field Engineer's or Formulator Versions.

hyd-RO-dose R_x Files

The hyd-RO-dose series uses three (3) file types in addition to those used and generated by the original hyd-RO-sat program. The original files included the .HYD work files, and the .PCX, .BMP and .TIF graphic output files, and the .MBR membrane specification files. The hyd-RO-dose R_x series adds the .PRD product information file, the .INH inhibitor correlation file, and the .COR, laboratory data for correlation file.

hyd-RO-dose Files -

Workspace Files: .HYD files store water analysis entered into hyd-RO-dose, units information, ""What-if" parameters, and any indices which were calculated prior to being stored in .HYD file format. .HYD files are hyd-RO-dose work files which allow you to stop work, save what you have completed, and return at another time. A .HYD file returns the hyd-RO-dose program, analysis, and values to the same condition they were when the file was saved.

Membrane Files: .MBR files store the ion rejection specifications for membranes. A separate .MBR file is required for each membrane type.

Graphic Files: .PCX files are a standard graphic format used to store pictures on the screen for transfer to other programs. hyd-RO-dose creates a type 5 .PCX file with all color (palette) information stored as well as the graphic information.

.BMP files are standard Windows bitmap files.

.TIF are another standard bitmap format for graphics.

hyd-RO-dose R_x Field Engineer Edition Files -

The Field Engineer Edition creates the same files that are created by the original hyd-RO-dose program. The Field Engineer Edition .HYD file includes any dosage recommendations calculated prior to the file being saved as well as information on the current product.

Product Files: The Field Engineer Edition uses (but cannot create, modify, or display) product information files (.PRD). .PRD files contain product formulation information such as active ingredients and their percentages. This information is used in conjunction with mathematical inhibitor model coefficients to calculate dosage recommendations. The Field Engineer Edition can use the information in the files, but is not capable of displaying this sometimes proprietary information. The active ingredient list, and their percentages, cannot be obtained by loading a product (.PRD) file into the Field Engineer Edition program.

hyd-RO-dose R_x Formulator Edition Files -

The Formulator Edition creates the same files that are created and used by the original hyd-RO-dose program. Additionally, the Formulator Edition can create product (.PRD) files. It can also access inhibitor (.INH) files.

The Formulator Edition can create, modify, and display product information files (.PRD). The INPUT FORMULATION module is used to access or create a .PRD file. Active ingredients information is added to the .PRD files through the loading of the inhibitor file for the active ingredient being added. The appropriate percentage(s) for active ingredients thus loaded are entered into the form. The inhibitor (.INH) files contain the mathematical inhibitor model coefficients to calculate dosage recommendations. The Formulator Edition can use the information in the .INH files, but is not capable of displaying this sometimes proprietary information, or the laboratory data which was used to generate the inhibitor correlations.

The Formulator Edition has full access to the formulation information such as active ingredients, and their percentages. The Formulator Edition can also create membrane specification files (.MBR). Membrane Specification files are created by entering the specific ion rejection coefficients for a membrane type into the INPUT SPECS form, and saving as a .MBR file.

hyd-RO-dose R_x Laboratory Edition Files -

The Laboratory Edition creates the same files that are created by the original hyd-RO-dose program. The Laboratory Edition has all of the capabilities of the Formulator Edition. It can create product (.PRD) files.

Additionally, the Laboratory Edition can be used to directly edit inhibitor (.INH) files. The Laboratory Edition has the unique capability of processing .COR file data to generate inhibitor (.INH) files.

The Laboratory Edition can create, modify, and display product information files (.PRD). The Laboratory Edition has full access to .INH files, including the capability of displaying the sometimes proprietary information stored in them.

The Laboratory Edition has full access to laboratory and field data stored in .COR files. .COR files contain water chemistry information, dosage required for 100% inhibition, and temperature data for laboratory and/or field data. A series of analysis can be used to statistically model the inhibitor performance and develop a .INH file mathematical model. A minimum of five (5) analysis are required for a .COR file to be used.

GETTING STARTED

System Requirements

Installation

Selecting Analytical Units

System Requirements

As a general rule, French Creek Software programs will run on the minimum system configuration for a given Windows operating system. Performance increases with memory and processor speed. Suggested minimums are as follows.

The program requires approximately 700 mb of hard drive space for a full installation.

Please note that each workspace file will consume up to 50K of hard drive space. Each graph stored as a PCX file will use around 50K. Each graph stored as a .BMP file can take up to 600K of hard drive space.

INSTALLATION

BEFORE YOU DO ANYTHING ELSE, WHY NOT MAKE A BACKUP COPY OF THE INSTALLATION PROGRAM. PUT THE ORIGINAL CD IN A SAFE PLACE. IF YOU DOWNLOADED THE INSTALLATION PROGRAM BACK IT UP TO A CD OR OTHER MEDIA.

The program is installed like most Windows software: by running the SETUP.EXE file on the installation CD.

1) Insert the program CD.

2) Use the Windows RUN command to execute

SETUP.EXE <press enter>

You can also execute by double clicking on the SETUP.EXE program icon from FILE MANAGER, FILE EXPLORER, or MY COMPUTER, depending on your version of Windows.

3) The install program will search for an existing installation. You must install to the HYDRO directory, e.g. C:\HYDRO or D:\HYDRO ...

4) Execute the program by clicking on the French Creek Software Icon, by using the Windows RUN command, or from the Windows START menu.

Selecting Analytical Units

The first time hyd-RO-dose is run, it will display a warning that default analytical input units are in affect. This is a reminder to run the Input Units module in the preferences menu and choose the analytical reporting units used by your company.

ANALYTICAL UNITS SELECTION

Calcium	(as Ca)	Iron	(as Fe)	Sulfide	(as H2S)
Magnesium	(as Mg)	Ammonia	(as NH3)	Silica	(as SiO2)
Barium	(as Ba)	Aluminum	(as Al)	Phosphate	(as PO4)
Strontium	(as Sr)	Boron	(as B)	Fluoride	(as F)
Sodium	(as Na)	Chloride	(as Cl)	Nitrate	(as NO3)
Potassium	(as K)	Sulfate	(as SO4)	Temperature	(as °C)
Lithium	(as Li)	Acidiv	(as CO2)	Pressure	(Atm.)
pH	(pH Units)	M Alkalinity	(as HCO3)	pCO2	(psia)
Residence time	(seconds)	P Alkalinity	(as CO3)	Densitu	(mg/L)
Date	MM/DD/YR	Flow Rates	gpm	Corrosion rate	mpv

Standard Units

As The Ion

As CaCO3

Combination

epm

REPORTED AS

ppm

mg/l

epm

BALANCING IONS

CATIONS

Sodium

Potassium

ANIONS

Chloride

Sulfate

Nitrate

OK

Cancel

Analytical units are available for almost any reporting method in use. Date format can also be changed in this module. You might also wish to select the ions which will be used to balance incomplete water analyses.

Selecting Windows To Display

hyd-RO-dose displays an enormous amount of information. At times a total display is useful. At other times too much information is confusing or a nuisance. You can determine which informational output windows will be displayed after inputting analyses or running a 'What-if Scenario.'

These forms allow you to customize the display of these output windows.

Select Windows To Display And When To Display Them

After Raw Water Input

- Display Raw Water Analysis Window
- Display Raw Water Deposition Potential Window

After Concentrate

- Display Raw Water Analysis Window
- Display Raw Water Deposition Potential Window
- Display Analysis Summary Window (Raw, Feed, Product, Brine)
- Display Deposition Potential Summary Window

After Vary Recovery

- Display Raw Water Analysis Window
- Display Raw Water Deposition Potential Window
- Display Water Analysis versus % Recovery Window
- Display Water Deposition Potential versus % Recovery Window

After Vary pH

- Display Raw Water Analysis Window
- Display Raw Water Deposition Potential Window
- Display Water Analysis versus pH Window
- Display Water Deposition Potential versus pH Window

OK Cancel

It is recommended that new users set all windows to display. They can be deactivated and reactivated as desired using these forms.

CHOOSING DATA TO PRINT

You can also determine what analytical values and indices will be included in printouts by activating or deactivating individual items in the **Choose Ions To Print** and **Choose Scales To Print** forms, which can be accessed from the **Preferences** menu.

Select Chemistry Items To Print

CATIONS

- Calcium
- Magnesium
- Barium
- Strontium
- Sodium
- Potassium
- Lithium
- Ammonia
- Aluminum
- Iron
- Boron

ANIONS

- Chloride
- Sulfate
- Bromine
- Silica
- Acidity (or CO₂)
- M Alkalinity (or HCO₃)
- P Alkalinity (or CO₃)
- Sulfide
- Phosphate
- Fluoride
- Nitrate

PROPERTIES

- pH
- Temperature
- Calculated T.D.S.
- Density
- Pressure
- Dosage
- Corrosion Rate

OK SELECT ALL Cancel

Deposition Indicators To Print

Saturation Levels

- Calcite
- Aragonite
- Witherite
- Strontianite
- Magnesite
- Anhydrite
- Gypsum
- Barite
- Celestite
- Fluorite
- Tricalcium phosphate
- Hydroxyapatite
- Amorphous Silica
- Brucite
- Magnesium Silicate
- Iron hydroxide
- Strengite
- Siderite

Momentary Excess

- Calcite
- Aragonite
- Witherite
- Strontianite
- Magnesite
- Anhydrite
- Gypsum
- Barite
- Celestite
- Fluorite
- Tricalcium phosphate
- Hydroxyapatite
- Amorphous Silica
- Brucite
- Magnesium Silicate
- Iron hydroxide
- Strengite
- Siderite

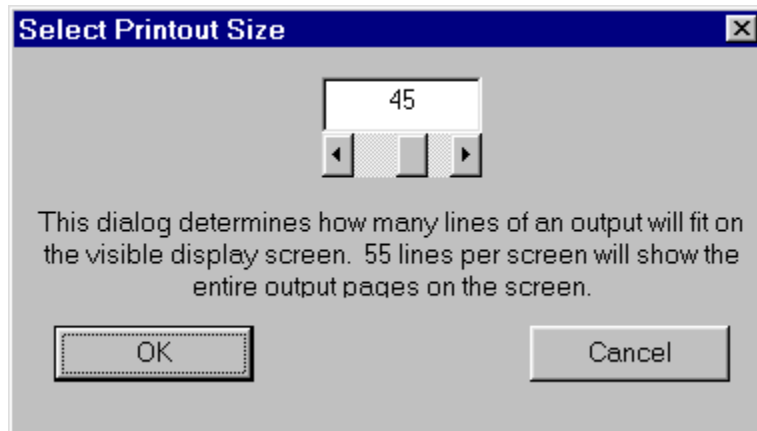
Simple Indices and Indicators

- Langelier
- Ryznar
- Puckorius
- Larson-Skold
- Stiff-Davis
- S.D.I.
- Free vs Total Ca
- Free vs Total Ba
- Free vs Total CO₃
- Free vs Total PO₄
- Free vs Total SO₄

OK Cancel

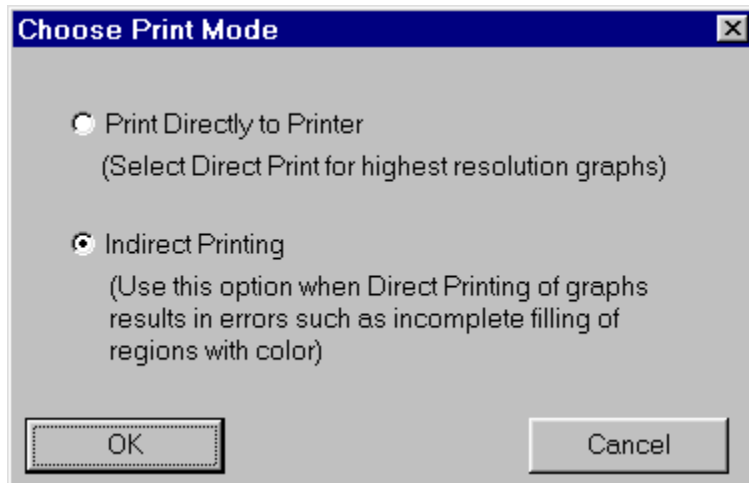
CHOOSING DISPLAY SIZE

The **Output Size On Screen** form allows you to select the number of lines from a printout that will be display on the screen. This allows you to size the output window so that an entire printout can be displayed on the screen. This form is also accessed through the **Preferences** menu.



PRINT MODE

The final setup form is rarely needed. It allows the selection of either directly printing to a printer or printing indirectly by preparing the printout in the computer's memory prior to transmitting to the printer. Choose Direct Print initially. Change your selection to Indirect Print if problems are encountered printing graphs.



SYSTEM & MEMBRANE SPECIFICATIONS

System Specifications

Selecting Membrane Type

Creating A New Membrane File

System Specifications

The hyd-RO-dose program series uses the specifications entered into the SYSTEM PARAMETERS modules for calculations of concentrate and product chemistry. Flow units can be changed in the Input Units module. The % Recovery entered in this module will be used by other modules as a basis for calculations.

System Specifications

Feedwater Flowrate: 10000 gpm

Product Flowrate: 7500 gpm

% Recovery: 75

Brine Flowrate: 2500 gpm

SYSTEM OPERATING PARAMETERS

Hours per Day	24.
Days per Week	7.
Weeks per Year	52.
Load Factor (0 - 100%)	95.

MEMBRANE SELECTION

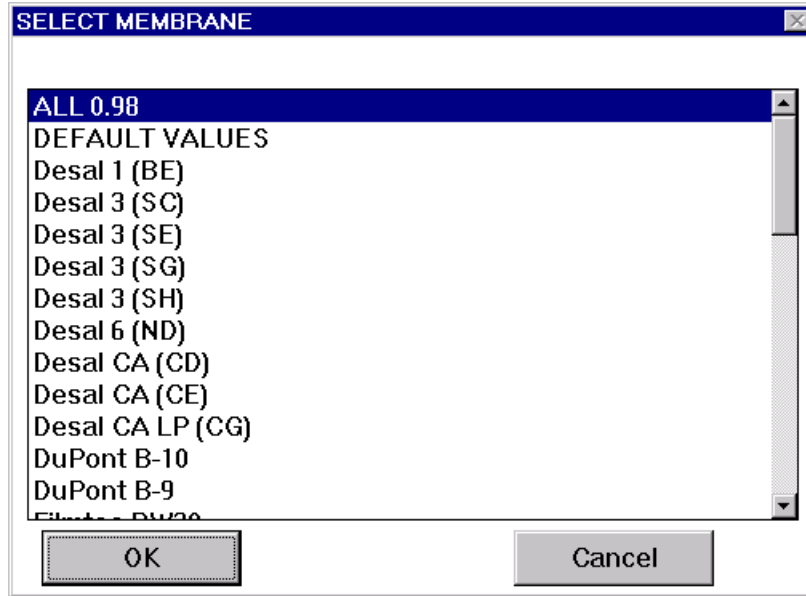
Press the MEMBRANE button to select a membrane appropriate to your system.

MEMBRANE | DEFAULT VALUES

OK PRINT RECALCULATE COPY CANCEL

Selecting Membrane Type

The membrane type can be selected in the Specifications module of the INPUT pulldown menu. Press the MEMBRANE button and select the membrane closest to that used in the system under study.



If the membrane in use is not on file, a .MBR file can be created by accessing the Membrane module in the SYSTEM PARAMETERS section.

Individual Ion Rejection (Fraction NOT %)

Membrane Type: TriSep A-15 File Name: A15.MBR

Calcium	0.985	Iron	0.992	CO2	0.09
Magnesium	0.98	Ammonia	0.95	HCO3	0.925
Barium	0.97	Aluminum	0.995	CO3	0.97
Strontium	0.975	Boron	0.96	Hydrogen sulfide	0.07
Sodium	0.96	Chloride	0.97	Silica	0.95
Potassium	0.955	Sulfate	0.985	Phosphate	0.99
Lithium	0.968	Nitrate	0.935	Fluoride	0.94

INITIALIZE TO SAME VALUE

Enter a value between 0.0 and 1.0 in this box, press the MAKE SAME button, and all specific ion rejections will be initialized to this default value.

MAKE SAME

OK Choose Membrane Save Membrane Cancel

Enter specific ion rejection values as a fraction.

"WHAT-IF" SCENARIO MODELING

"What-if Scenarios"

pH Prediction

"WHAT-IF" SCENARIO MODELING

What-if scenario modeling provides one of the greatest benefits from using hyd-RO-dose™. The WHAT-IF SCENARIO modules allow you to visualize what will happen to the scale potential and corrosivity of a water as environmental parameters and water chemistry change. The What-If scenarios allow you to evaluate the impact of bringing a water to the surface, or of mixing waters under varying conditions to find the safe ratios for mixing. The What-If's also provide a predictor for use in anticipating problems in new or proposed wells.

The What-If scenarios allow you to evaluate the scale potential of a water over the % recovery range expected, and the pH range encountered. Input parameters for selecting the What-If scenario ranges can be run with and without acid feed for pH control. All of the What-if Scenario modules can be run versus pH,

SCALES MODELED BY hyd-RO-dose

Calcite	CaCO ₃
Aragonite	CaCO ₃
Witherite	BaCO ₃
Magnesite	MgCO ₃
Siderite	FeCO ₃
Barite	BaSO ₄
Anhydrite	CaSO ₄
Gypsum	CaSO ₄ *2H ₂ O
Celestite	SrSO ₄
Fluorite	CaF ₂
Amorphous Iron	Fe(OH) ₃
Amorphous Silica	SiO ₂
Brucite	Mg(OH) ₂
Strengite	FePO ₄ *2H ₂ O
Tricalcium phosphate	Ca ₃ (PO ₄) ₂
Hydroxyapatite	Ca ₅ (PO ₄) ₃ (OH)
Thenardite	Na ₂ SO ₄
Halite	NaCl
Iron sulfide	FeS

SIMPLE INDICES

Stiff-Davis
Ryznar
Puckorius
Larson Skold

CONVENIENCE GROUPS

Three CONVENIENCE GROUPS have been programmed into hyd-RO-dose™ to allow multiple graph selection of common groups.

- The **Common Foulants Group** includes Calcite (CaCO₃), Barite (BaSO₄), Witherite (BaCO₃), and Anhydrite (CaSO₄) saturation levels.
- The **Common Indices Group** includes the Langelier, Stiff-Davis, Oddo-Tomson and Ryznar.
- The **Calcium Carbonate Group** includes Calcite saturation level, Langelier saturation index, the Stiff-Davis index, and the Oddo-Tomson index.

What-if Scenarios

Three scenario types can be run for membrane systems. The scenarios calculate the indicators of scale potential and corrosivity versus pH, recovery, or both. The modules are called VARY RECOVERY, VARY pH, and 3D PROFILE for these scenarios.

Prior to running any of these modules, setup the profiles and “what-if” parameters in the Select Parameters module. This module requests information on the minimum and maximum pH, minimum and maximum recovery, acid feed options, and pH prediction methods for the scenario calculations.

'What-if' Scenario Specifications

pH Range Selection
Low pH High pH Increment %

Recovery Range Selection
Low % High % Increment %

pH Control Method

Acids
 93% H₂SO₄
 98% H₂SO₄
 35% HCl
 CO₂
 NONE

Alkalies
 Caustic soda (NaOH)
 Caustic potash (KOH)
 Soda ash (Na₂CO₃)
 Sodium bicarbonate (NaHCO₃)
 Lime (Ca(OH)₂)
 NONE

Control pH of
 Feedwater
 Brine

pH Target

CO₂ Exchange
 Totally Closed (Conserve CO₂ - Total Carbon)
 Vented (Conserve Alkalinity)

pH Prediction Method
 Mfgr's Method (Conserve CO₂)
 Translate Source pH
 User Curve
 Default Curve
 Caplan Curve

OK Cancel

The first graph selected for a series of profiles takes the longest. All indices are calculated during the first run of the "What-If" scenario. Once they are calculated, recalculation is not required until you change either the pH, recovery, temperature, or water chemistry.

Once a graph is displayed, it can be printed, or saved as a graphics file. A menu bar at the top of the graph window provides options for working with graph. Options include Printing, Displaying and Exporting the graph as a color or gray scale format.

The CHOOSE GRAPHS module should be used to select the graphs desired. Once a graph is displayed on the screen, it can be saved as a PCX, BMP, or TIF file for use in other programs such as word processing programs, or printed. Like the other modules, the ALT and G hot key combo will pop-up the CHOOSE GRAPHS menu. The ALT and F hot key combo will pop-up the SAVE FILE menu for saving a graph as a PCX file, and the ALT P combo will print the graph to the selected printer.

Calculated values used to plot the 3Dgraphs can be exported as quotation mark-comma delimited ASCII files. These .DAT files can be imported into most spreadsheet and graphics programs and used to recreate graphs, or further manipulate the data.

pH PREDICTION

Predicting pH as the water concentrates is one of the more difficult aspects of computer modeling. hyd-RO-dose provides several options, chosen from the **SELECT PARAMETERS** menu form.

- The **MANUFACTURER'S METHOD** uses pH:Alkalinity predicting pH in a totally closed system and assumes no CO₂ exchange with the atmosphere. This method is recommended when *totally closed* is selected for the CO₂ exchange type.
- The **TRANSLATE SOURCE pH** is recommended when *vented* is selected for the CO₂ exchange type.
- The **DEFAULT** curve is a pH:Alkalinity curve which is used by several of the major water treatment companies for predicting pH from alkalinity. This is included for compatibility with previous versions and should only be selected for *vented* systems.
- The **USER DEFINED** curve uses data input in the **INPUT pH-ALKALINITY** module to predict pH from alkalinity.

The **Caplan curve** is similar to the default curve. It is derived from a paper published by Gary Caplan at Corrosion '90 (NACE). This is included for compatibility with previous versions and should only be selected for *vented* systems.

The pH control point selected will depend on your perspective. Chemists will typically be interested in the pH of the brine (concentrate), and would select the Brine as the pH control point. An operator would be more interested in the pH of his feed water, and would choose Feedwater as the pH control (measurement) point.

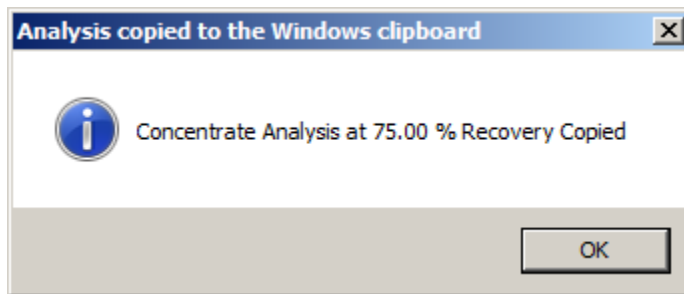
In either case, acid requirements projected will be mg/L of acid feed to the Raw Water. When the control point is the brine, the acid feed (or alkali feed) projected is the feed to the raw water required to control the pH in the brine. When the control point is the Feedwater, the projected acid or alkali requirement is the feed required to adjust the raw water pH to the desired feedwater pH.

Please note that pH profiles can not be run unless an acid and/or alkali is selected.

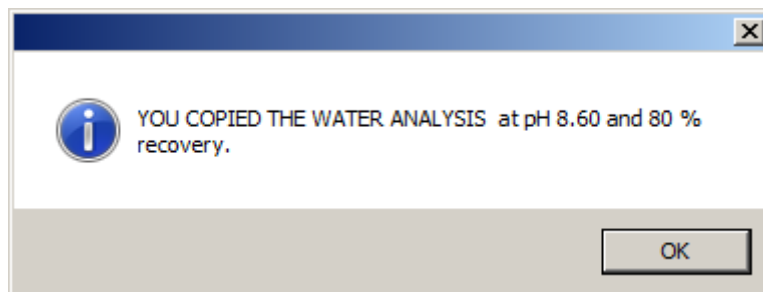
COPY and PASTE BETWEEN PROGRAMS

If you right click on the top of a 3D graph bar, or a 2D graph bar, the water analysis for that point will be copied to the Windows clipboard and can be pasted into other French Creek programs. For example, you can right click on the top of the 3D bar for your expected % Recovery and pH, copy the analysis for this concentrate to the Windows clipboard, and paste it into the mixing input forms of a French Creek program like DownHole SAT[™], MineSAT[™], or WatSIM[™]. Paste into DownHole SAT for deep injection well disposal to check compatibility with the aquifer.

You can also right click on a column in any table to copy the analysis to the Windows clipboard. hyd-RO-dose will acknowledge that the copy was successful.



or from 3D graphs



Raw water can be copied or pasted using the COPY and PASTE buttons on the Input Form.

Raw Water Chemistry Input

Sample Date Time ID# Report Date

Sample Description

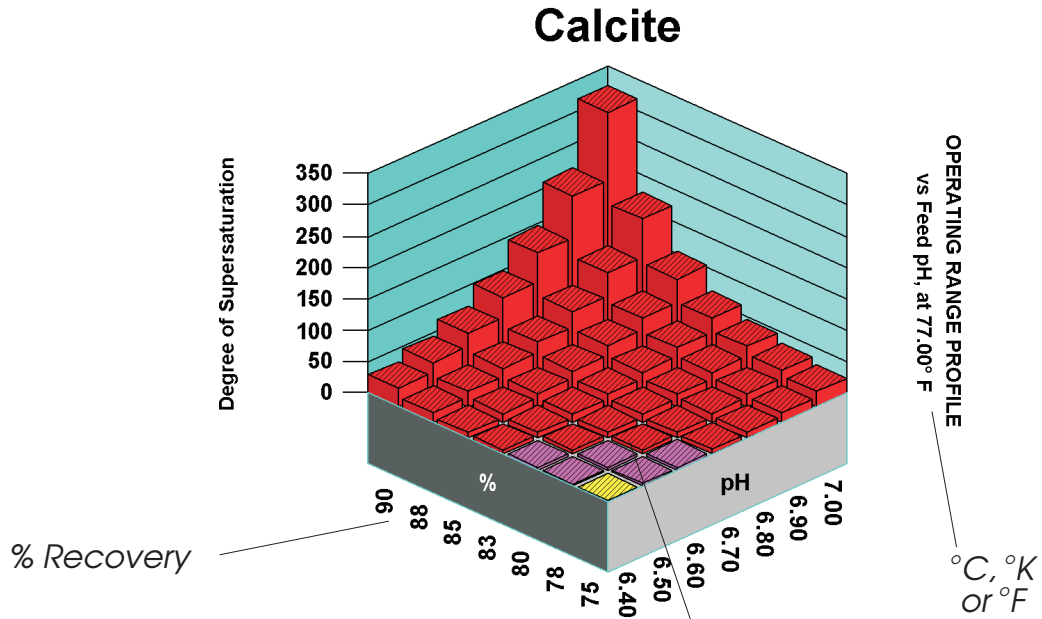
Calcium (as Ca)	<input type="text" value="111.00"/>	Iron (as Fe)	<input type="text" value="0.00"/>	Hydrogen sulfide (as H2S)	<input type="text" value="0.00"/>
Magnesium (as Mg)	<input type="text" value="0.00"/>	Ammonia (as NH3)	<input type="text" value="0.00"/>	Silica (as SiO2)	<input type="text" value="0.00"/>
Barium (as Ba)	<input type="text" value="0.00"/>	Aluminum (as Al)	<input type="text" value="0.00"/>	Phosphate (as PO4)	<input type="text" value="0.00"/>
Strontium (as Sr)	<input type="text" value="0.00"/>	Boron (as B)	<input type="text" value="0.00"/>	Fluoride (as F)	<input type="text" value="0.00"/>
Sodium (as Na)	<input type="text" value="0.00"/>	Chloride (as Cl)	<input type="text" value="131.91"/>	Nitrate (as NO3)	<input type="text" value="0.00"/>
Potassium (as K)	<input type="text" value="0.00"/>	Sulfate (as SO4)	<input type="text" value="0.00"/>	Temperature (as °C)	<input type="text" value="25.00"/>
Lithium (as Li)	<input type="text" value="0.00"/>	Dissolved CO2 (as CO2)	<input type="text" value="20.35"/>	Density (g/mL)	<input type="text" value="1.00"/>
pH(raw) (pH Units)	<input type="text" value="7.00"/>	Bicarbonate (as HCO3)	<input type="text" value="111.00"/>	Pressure (Bars)	<input type="text" value="1.00"/>
Residence time (seconds)	<input type="text" value="1500"/>	Carbonate (as CO3)	<input type="text" value="0.00"/>	Silt Density Index	<input type="text" value="0.00"/>

Comments

Balance
TDS (mg/L) EPM Cations EPM Anions

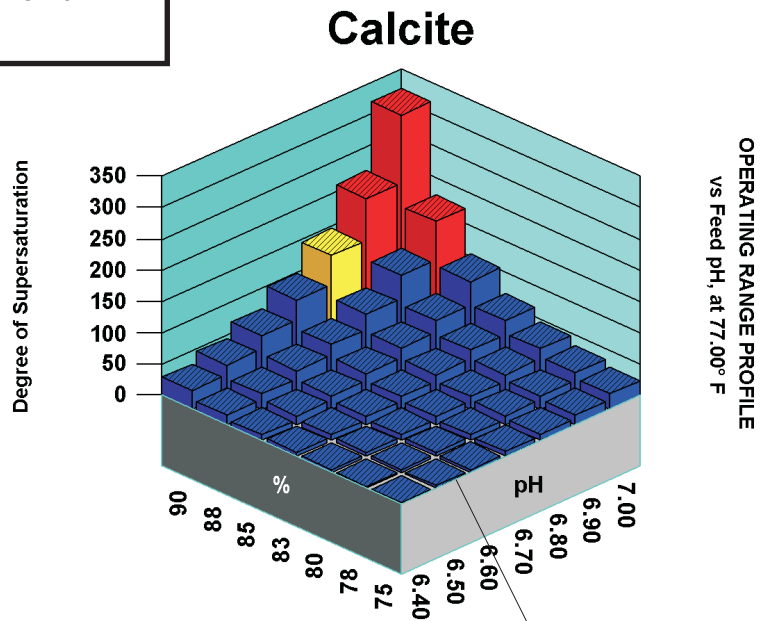
hyd-RO-dose

Compares The Safe Operating Range For a Treated versus Untreated System



Choose the **"Treated"** or **"Untreated"** color coding option from the Options Pop-up Menu.

The RED color code indicates potential trouble.



The BLUE color code indicates a safe zone for operation.

OPTIMIZING TREATMENTS

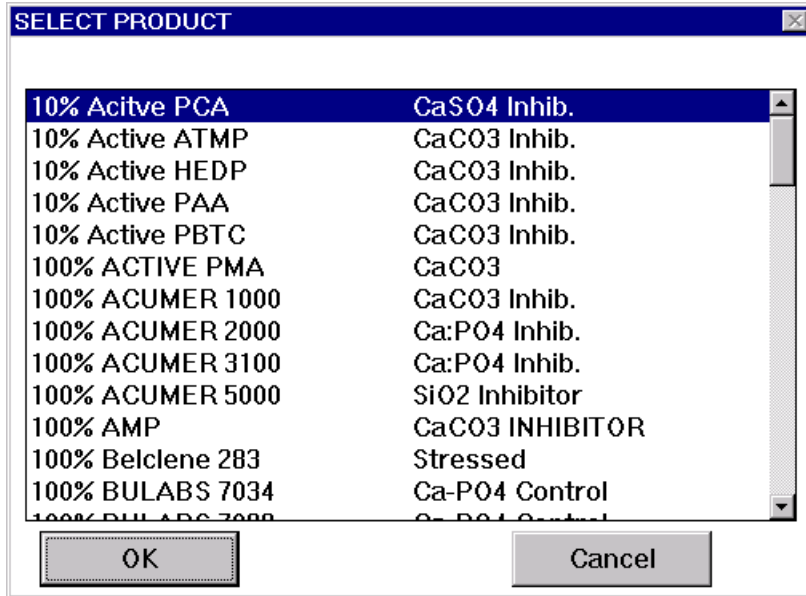
Selecting A Product

Inputting A Product Formulation

Developing Inhibitor Models

SELECTING A PRODUCT

Products can be selected using the Select Product module in the ANTISCALANT pull down menu.



Each product listed represents a product file (.PRD) located in the \HYDRO\INHIB\ directory. This module can also be accessed from the menu bar atop the graphic window when a graph is displayed.

CHECKING PRODUCT LIMITS

You can compare the limits for a product to the actual conditions and chemistry by clicking the **CHECK LIMITS** selection. This is helpful if you need to find out why a dosage profile is not BLUE or is in brackets. It describes what scale, index, or ion is out-of-limit.

Product:	Ca,Ba,Sr, Antiscalan			
Parameter	Current Value	Lower Limit	Upper Limit	Status
Calcite [CaCO3]	29.282	N/A	150.	OK
Gypsum	0.89954	N/A	4.	OK
Celestite [SrSO4]	0.33585	N/A	12.	OK
Barite [BaSO4]	142.2	N/A	80.	ABOVE LIMIT
Amorphous Silica	0.	N/A	1.	OK
Fluorite [CaF2]	8.8019e-002	N/A	120.	OK
Iron	7.6e-002	N/A	0.2	OK
Aluminum	0.	N/A	0.2	OK
Langelier Index	1.6804	N/A	2.5	OK
Ryznar Index	4.7	3.3	N/A	OK
Puckorius Index	4.2954	3.3	N/A	OK
Aragonite [CaCO3]	25.212	N/A	135.	OK

The **CHECK LIMITS** form can be accessed from the **SYSTEM CHEMISTRY** summary displayed when you **CONCENTRATE** from the **WHAT-IF** menu.

SYSTEM CHEMISTRY AT 75.0 % RECOVERY

OPTIONS NEW TREATMENT CHECK LIMITS

Sample ID: 0 Report Date: 17-09-2004 Sampled: 17-09-2004 at 1246

CATIONS	Raw water	Feedwater	Product	Brine
Calcium(as Ca)	111.00	111.00	7.40	421.80
Magnesium(as Mg)	11.00	11.00	0.733	41.80
Barium(as Ba)	0.500	0.500	0.0333	1.90
Strontium(as Sr)	2.00	2.00	0.133	7.60
Sodium(as Na)	133.08	133.08	8.87	505.69
Potassium(as K)	0.00	0.00	0.00	0.00
Lithium(as Li)	0.00	0.00	0.00	0.00
Iron(as Fe)	0.0200	0.0200	0.00133	0.0760
Ammonia(as NH3)	0.00	0.00	0.00	0.00
Aluminum(as Al)	0.00	0.00	0.00	0.00
Boron(as B)	0.00	0.00	0.00	0.00
ANIONS				
Chloride(as Cl)	131.46	131.46	8.76	499.55
Sulfate(as SO4)	300.00	300.00	20.00	1140
Dissolved CO2(as CO2)	16.65	16.65	1.11	10.72
Bicarbonate(as HCO3)	138.14	138.14	9.23	556.79
Carbonate(as CO3)	0.394	0.394	< 0.001	21.04
Silica(as SiO2)	0.00	0.00	0.00	0.00
Phosphate(as PO4)	0.100	0.100	0.00667	0.380
H2S (as H2S)	0.00	0.00	0.00	0.00
Fluoride(as F)	1.00	1.00	0.0667	3.80
Nitrate(as NO3)	0.00	0.00	0.00	0.00
PARAMETERS				
pH	7.20	7.20	5.52	8.06
Temperature (Deg F)	77.00	77.00	77.00	77.00
Calculated T.D.S.	845.37	845.37	56.36	3211
Calculated Cond.	1167	1167	98.31	3473
DOSAGE				
PAA (mg/L)	[30.0]			[119.9]



INPUTTING A PRODUCT FORMULATION

The Input Product module, in the FORMULARY pull down menu is used to create a product (.PRD) file. The Input Product module is available only in the hyd-RO-dose Rx Formulator and Laboratory Editions.

Use the Input Product module to create a new product file or modify an existing product file's Product Name, Description, or Formulation. All entries are made in the form reproduced on the next page. The Product Name and Description information entered are stored in the product file and used as the Product Name and Description list in the Select Product module pop up menu.

Inhibitors MUST be selected from the pop-up menu list of available inhibitors on file. Move the cursor to the Inhibitor Field. Press F2 to pop-up the list of available inhibitors. Select the inhibitor of interest. The inhibitor file will be loaded for the ingredient selected.

Inhibitor	Inhibitor Name	Percentage
Inhibitor 1	PAA (SrSO4)	30.000 %
Inhibitor 2	PAA (BaSO4)	30.000 %
Inhibitor 3	PAA (CaF2)	30.000 %
Inhibitor 4	PAA (CaSO4)	30.000 %
Inhibitor 5	PAA (CaCO3)	30.000 %
Inhibitor 6		0.000 %
Inhibitor 7		0.000 %

Formulation Name: PAA 30 Description: Ba, Ca, Sr Antiscalant
Product File Name: PAA30.PRD

Minumum Dosage: 2.000 (mg/L) % Actives: 150.000 %
Password: % Water: -50.000 %

Buttons: OK, Calc %, Set Limits, Delete File, Help, Cancel

ENTER THE % IN THE FORMULATION BASED UPON 100% ACTIVE INGREDIENTS!! e.g. if you are using a material which is 50% active AMP, and you wish to have the product be 10% active, you would enter 20% on a manufacturing batch sheet for the material on an "as-

is" basis. Enter 10% on the hyd-RO-dose Rx formulation sheet for the material on an active basis.

hyd-RO-dose will total the active ingredients and balance the formula with water.

Pressing the OK button saves the formulation and inhibitor information in the product (.PRD) file named in the File Name field. Copies of this file can be distributed to users of the hyd-RO-dose Rx Field Engineer Edition program.

NOTE: Inhibitors should be re-loaded into a formulation sheet when an inhibitor file is updated. Product files load a copy of the inhibitor file when they are created. They DO NOT automatically re-load a new file when the inhibitor data is updated.

NOTE: If models for more than one scale are loaded for a given inhibitor, each model should be entered at the active percentage. e.g. if a product is 30% PAA and you load the BaSO4 inhibitor model, the CaCO3 inhibitor model, and the SrSO4 model, each should be given the value of 30% Your total may exceed 100%. The program will treat the product as the appropriate percent active, 30% in this case.

NOTE: The minimum dosage is the minimum dosage the program will recommend in the brine.

The module accepts input data for a product file, loads the mathematical correlations for the individual inhibitors in the formulation, and outputs the new or updated product file.

An inhibitor file (*.INH) must be in the \WATER\INHIB\ sub directory for each inhibitor which is an active ingredient.

Inhibitor files are created in the Input Lab Data module of the LABORATORY pull down menu in the hyd-RO-dose Rx Laboratory Editions. They can be created from in-house laboratory and/or field data, or obtained from raw material suppliers who use the hyd-RO-dose Rx series as a technical support tool.

SETTING PRODUCT LIMITS

Press the SET LIMITS button in the INHIBITOR FORMULATION INPUT FORM to access the PRODUCT LIMITS INPUT FORM. This is available in Formulator and Laboratory Editions.

Product Limits Input Form [X]

Formulation: PAA 100 Description: Ba, Ca, Si Product File: PAA100.PRD

Limit Active?	Lower Limit	Upper Limit	Description	Limit Active?	Lower Limit	Upper Limit	Description
<input checked="" type="radio"/>	-99.00	150.00	Calcite Saturation Level	<input type="radio"/>	-99.00	-99.00	Puckorius Index
<input checked="" type="radio"/>	-99.00	4.00	Gypsum Saturation Level	<input type="radio"/>	-99.00	-99.00	Stiff Davis Index
<input checked="" type="radio"/>	-99.00	12.00	Celestite Saturation Level	<input type="radio"/>	-99.00	-99.00	TCP Saturation
<input checked="" type="radio"/>	-99.00	80.00	Barite Saturation Level	<input type="radio"/>	-99.00	-99.00	Hydroxylapatite Sat
<input checked="" type="radio"/>	-99.00	1.20	Amorphous Silica Saturation	<input checked="" type="radio"/>	-99.00	4.00	Anhydrite Saturation
<input type="radio"/>	-99.00	-99.00	Magnesium Silicate Saturation	<input type="radio"/>	-99.00	-99.00	Magnesite Saturation
<input checked="" type="radio"/>	-99.00	120	Fluorite Saturation Level	<input type="radio"/>	-99.00	-99.00	Siderite Saturation
<input type="radio"/>	-99.00	0.500	mg/L Iron as Fe	<input type="radio"/>	-99.00	-99.00	Strengite Saturation
<input type="radio"/>	-99.00	-99.00	mg/L Aluminum as Al	<input type="radio"/>	-99.00	-99.00	Ferric hydroxide Sat
<input checked="" type="radio"/>	-99.00	2.50	Langelier Saturation Index	<input checked="" type="radio"/>	-99.00	150.00	Aragonite Sat
<input checked="" type="radio"/>	-99.00	2.80	Ryznar Stability Index				

Activate a limit by clicking the radio button by an index or ion. Input the upper or lower limit. The program will “flag” dosages as out of range if they are above the upper limit set in this form, or below the lower limit. If no values are input or active in this form, limits in the inhibitor files loaded to make the product will be used. You can populate this form by pressing the SCAN INHIBITORS button. It fills in the limits from the inhibitor models loaded. You can over-ride these inhibitor file limits by entering values in this form and activating them with the radio button.

DOSAGE MODULATION

The section describes the basis for the models used by and developed using hyd-RO-dose Rx. Models are discussed by parameter.

DRIVING FORCE - The basic parameter to which scale inhibitor dosages have been correlated historically is the driving force for crystal formation, and crystal growth. Early models attempted to develop models based upon the Langelier Saturation Index or the Ryznar Stability Index. More recently, correlations have been published to the Practical Stability Index on the back of the Puckorius and Associates slide rule. Most water treaters are in agreement that dosage requirements increase with the driving force for scale formation. They differ in which driving force is used. Calcite saturation level provides an excellent driving force for calcium carbonate scale inhibitor models, gypsum saturation level for calcium sulfate in the cooling water temperature range, and tricalcium phosphate saturation level for calcium phosphate scale prevention. The Momentary Excess indices can also be used effectively to model dosage requirements. hyd-RO-dose Rx allows the water treatment chemist to develop models using any of the indices calculated by hyd-RO-dose.

TIME - A second critical factor in determining an effective dosage, or developing a model for an inhibitor is time. Time is the residence time of scale forming species in the system you wish to treat. The time where scale inhibition can be as short as 4 to 10 seconds in a utility condenser system, or extend into days for cooling towers. Induction time is a term applied to the period before a water will begin to form scale. In high saturation level systems, the induction period can be very short. In systems where a water is barely supersaturated, the induction time can approach infinity. Scale inhibitors have been observed to extend the induction time before scale formation, or growth on existing scale substrate, occurs. Gill et al. presented a paper at the 1984 International Water Conference which provides excellent examples of the variation of dosage requirements as critical parameters change.

Figure 1 portrays the impact of HEDP dosage on induction time at constant driving force.

IMPACT OF HEDP CONCENTRATION ON INDUCTION TIME

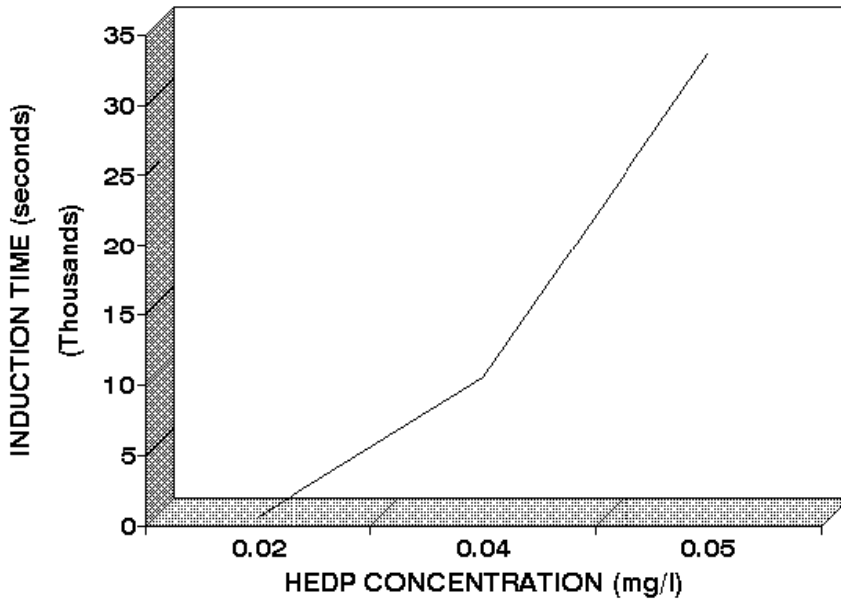
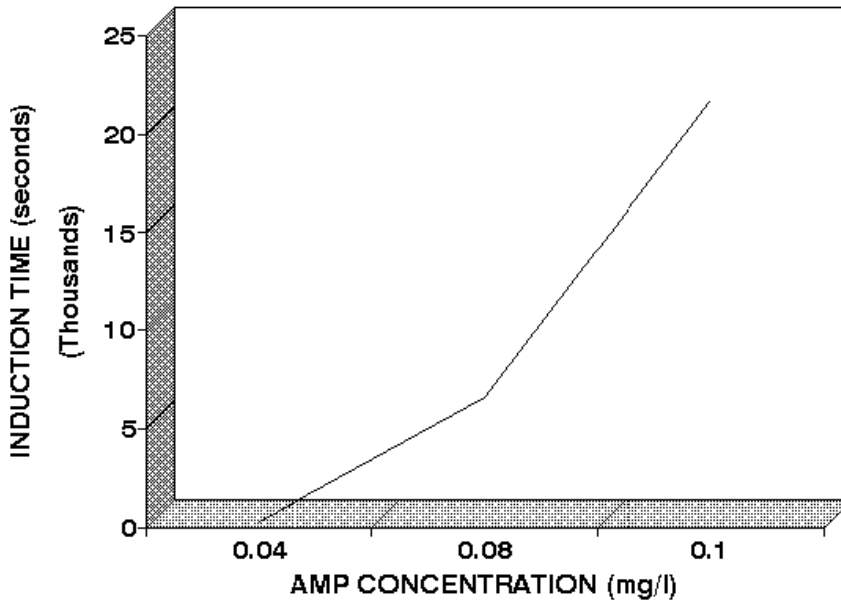


Figure 2 presents similar data for AMP.

IMPACT OF AMP CONCENTRATION ON INDUCTION TIME



It can be seen from figures 1 and 2 that induction time increases as inhibitor dosages increases. In cooling water systems, scale inhibitors may function by increasing the induction time until the water has passed through the system.

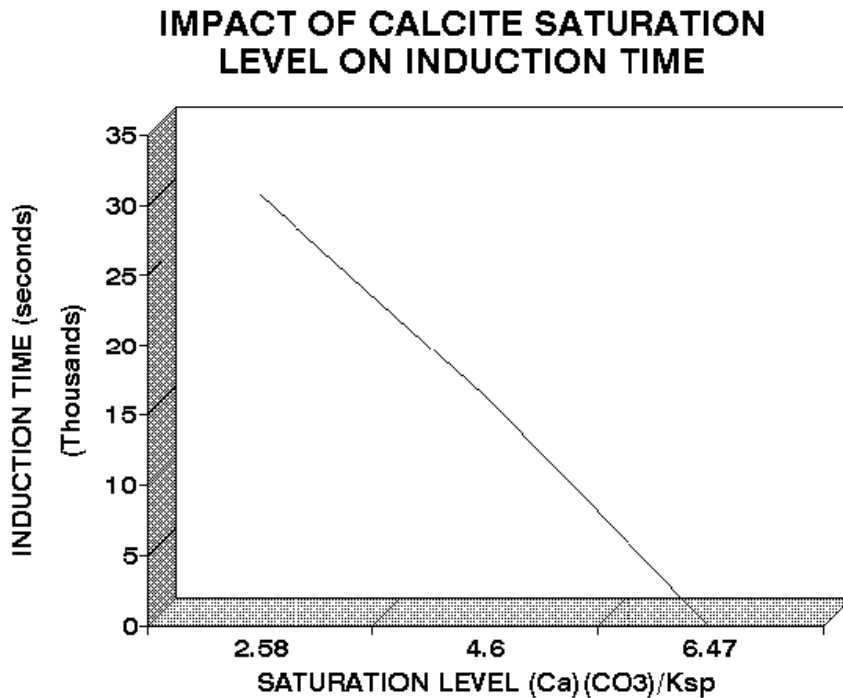


Figure 3 demonstrates that induction time decreases with saturation level, even in the presence of an inhibitor.

A simple mathematical description of these relationships might be modeled as:

$$\text{Induction Time} = \text{function}(1./\text{Saturation Level})$$

This models the decrease in induction time as saturation level increases. The degree of supersaturation is the driving force which increases the rate at which scale will form.

$$\text{Induction Time} = \text{function}(\text{Inhibitor Dosage})$$

Inhibitors extend the time before scale will form in a system by interfering with the kinetics of crystal formation and growth. Rate decreases as inhibitor dosages increase.

$$\text{Induction Time} = \text{function}(\text{Inhibitor Dosage}, 1./\text{Saturation Level})$$

In systems, the inhibitors fight the driving force for scale formation and growth. Inhibitors increase the induction time, and interfere with reaction rates, so that scale formation will not occur until the treated water has passed through the system.

hyd-RO-dose Rx uses more sophisticated relationships than these to model the dosage requirements for scale inhibition. Additional parameters include temperature, as it affects the rate of crystal formation and/or growth.

Dosage changes with temperature can be modeled by the Arrhenius relationship:

$$A \cdot e^{-(Ea/RT)}$$

where

- **A** is a constant
- **Ea** is the activation energy
- **R** is the gas constant
- **T** is absolute temperature.

pH can also be included in the models. pH is an important parameter to include when an inhibitor can exist in two or more forms within the pH range of use, and where one of the forms is much more active as a scale inhibitor than the other(s). pH can also affect the type of scale that forms (e.g. Tricalcium phosphate versus hydroxylapatite).

DEVELOPING INHIBITOR MODELS

This section describes the use of the Laboratory Edition Modules for:

- Inputting laboratory and field data to develop an inhibitor model.
- Editing inhibitor files to add special rules for handling iron.
- Editing inhibitor files to include a safety factor.

The Input Lab Data module, in the **LABORATORY** pull down menu is used to create inhibitor (.INH) file. The module accepts initial specifications for the inhibitor (e.g. Name, Description, Molecular weight) and instructions for developing a model (e.g. the Driving Force to use, the modeling method).

New Inhibitor Data Input

Inhibitor Name: PAA Raw Data File: PAA.COR

Inhibitor Purpose: CaCO3 Output File: PAA.INH

Property Modeled: Scale Inhibitor Dosage Calcite [CaCO3]

Molecular Weight: 2500.000000 % Orthophosphate as PO4: 0.000000 ID#: 0

Property	Variable	Transform	Lower Limit	Upper Limit
	Dosage	LOG(X)		
Variable 1	Calcite [CaCO3]	LOG(X)	-99.00	-99.00
Variable 2	Temperature	1/RT	-99.00	-99.00
Variable 3	Time	LOG(X)	-99.00	-99.00
Variable 4			-99.00	-99.00
Variable 5			-99.00	-99.00
Variable 6			-99.00	-99.00

OK Cancel

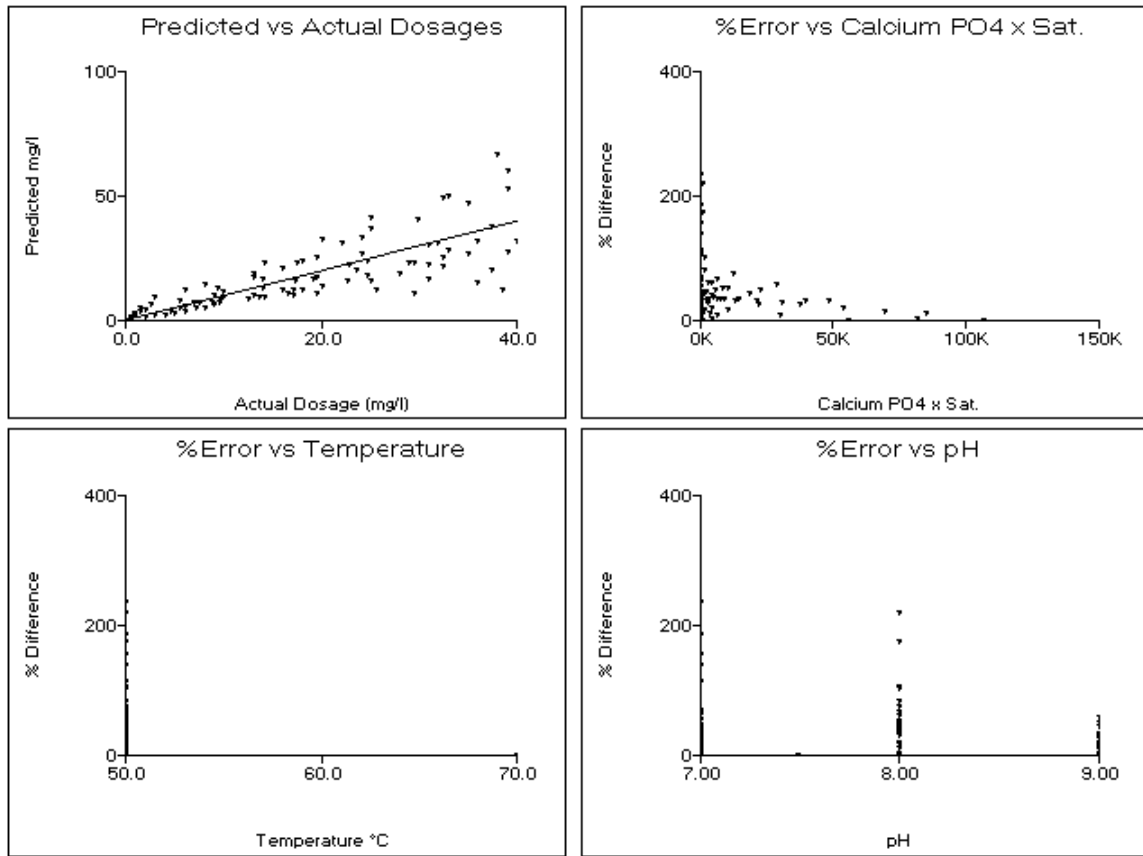
After this preliminary data is entered, and the Correlate button is pressed to signify completion, the module accepts input of water analysis data through almost the same analytical input form that is used in the Once Through Source Analysis module and Cooling Tower Make-up Analysis modules. The Input Lab Data form adds two (2) significant fields to the water analysis forms - dosage and time. The input form differs in another way - operation. The Lab Data Input Form replaces itself with a fresh form every time OK is pressed.

The Next Page and Last Page buttons allow you to browse through the analysis that have been input and make changes. The program will sound a warning when the first analysis on

file is reached. The program will ask if you wish to add another analysis when the last analysis is reached.

Once all data has been entered, press **Correlate** to invoke the statistical analysis of the data and generation of an inhibitor file. A table of predicted versus input dosages will be displayed. Use this table to determine crudely how well the data was modeled. A correlation coefficient is also output. Typical coefficients for usable models will range from 0.9 to 1.00 .

Pressing the Graph button will present further information on the correlation in graphical format.



The Input Lab Data module is available only in the hyd-RO-dose Rx Laboratory Edition. The Edit Coefficients module is used to add special rules and safety factors to the inhibitor files.

The raw laboratory analysis and calculated values are stored in a .COR file. The data is used to create an inhibitor (.INH) file.

OPERATION HINTS:

1. Enter inhibitor dosages on a **100% ACTIVE BASIS**.
2. Make backup copies of .COR files under another name. This will prevent anguish and stressed tempers when a .COR file with a thousand or so analysis is over-written unintentionally.

3. Always press Graph after completing the correlation to see the graphs of predicted versus observed dosages, and graphs of error % versus versus the independent parameters.
4. The Options Menu Bar allows correlation graphs to be saved as a .PCX , TIF or BMP file.
5. Always enter at least 5 valid analysis.

DEVELOPING LABORATORY DATA

A common question from hyd-RO-dose Rx users is What should I use for an experimental design? French Creek Software recommends that the experimental designs for developing mathematical models for inhibitors include:

FIVE TEMPERATURES PREFERRED: Data should be run at a minimum of three temperatures to account for variation in dosage due to the effect of temperature on reaction rate. When possible, an experimental design should include five temperatures. The temperature range studied should include the lowest and highest temperatures expected in the field, or where the models generated by hyd-RO-dose Rx.

THREE TO FIVE pH POINTS PREFERRED: Data should be run at a minimum of three different pH to account for variation in dosage due to the effect of pH on the form in which the inhibitor exists (see Hann and Bardsley). When possible, an experimental design should include five pH points. The pH range studied should include the lowest and highest expected in the field.

THREE TO FIVE INDUCTION PERIODS PREFERRED: Data should be run at a minimum of three different times to allow for the correlation of induction time versus inhibitor dosage. In some test methods, the times for each replicate will vary naturally. In other methods, dosages are evaluated at constant time extensions, and the last dosage to provide 100% inhibition is selected as the minimum effective dosage. Assure that the time spans covered by the data cover the full range over which you expect to use the model.

INCLUDE THE MINIMUM AND MAXIMUM FOR CRITICAL PARAMETERS: Tests should ideally be run over the range of parameters under which the model will be used for inhibitor dosage recommendations. For example, the experimental design should include the minimum and maximum driving force where the model will be used. If a calcium carbonate inhibitor is being evaluated, the range of calcium and hardness levels anticipated should be bracketed as well as the range of calcite saturation levels.

RUN SUPPLEMENTAL TESTS WHERE APPROPRIATE: Some inhibitors are known to lose activity in the presence of iron. Tests run in the presence and absence of iron can help to expand the accuracy of models by allowing an Iron Factor to be input using the Edit Coefficients module.

Several papers are referenced in the Appendix of this manual which outline test methods which have been used effectively to characterize the performance of inhibitors. Successful correlations can also be developed based upon the field experience of water treatment personnel have worked with an inhibitor over a broad range of conditions.

Example hyd-RO-dose Models

The following provide a guideline for developing basic models

1. **Dosage = f(DF-1, time)** The first model develops a correlation of dosage as a function of driving force, temperature, and time, The driving force selected for this, or other models, should be appropriate for the scale forming species under study. For example, calcite saturation level is a common driving force used to model calcium carbonate scale inhibitors. Tricalcium phosphate saturation level is a recommended driving force for use in modeling the effectiveness of calcium phosphate control agents. Gypsum saturation level is recommended for modeling calcium sulfate control at low (< 130 °F) temperature, while anhydrite saturation level might be more appropriate at higher temperatures. This model subtracts 1.0 from the saturation levels. This accounts for the driving force for scale formation not being present until the test water becomes supersaturated - at a saturation level above 1.0.
2. **Dosage = f(DF, time)** The second model differs from the first in that the correlation is developed to the raw driving force rather than to the driving force - 1.
3. **Dosage = f(DF-1, time, pH)** The third model is identical to model 0 with one exception. pH is included as a variable to account for the impact of pH upon the form in which an inhibitor exists. This is typically the model of choice for developing a correlation for a scale inhibitor.

DEACTIVATING ANALYSIS FILES

There will be times when it is desired to perform a statistical modeling of the data with the results of one or more analysis excluded from the evaluation. This can be valuable in eliminating outliers to see their impact. Pressing the ACTIVATE or DE-ACTIVATE buttons when an analysis is on the screen ACTIVATES or DE-ACTIVATES an analysis. Deactivating does not eliminate the data from the .COR file, it merely excludes it from statistical evaluation.

LEARNING THE LABORATORY MODULES

The best way to learn these modules is by using them. A .COR file is included for practice on modeling inhibitor performance and requirements.

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hyd-RO-dose[™] LICENSE AGREEMENT
FRENCH CREEK SOFTWARE, INC. (FRENCH CREEK)
Kimberton & Hares Hill Road, Box 684
Kimberton, PA 19442

French Creek has developed the automated capability to predict certain chemical properties of water samples. French Creek refers to this computer software as hyd-RO-dose, sometimes referred to as hyd-RO-dose or System in this Agreement.

hyd-RO-dose is a predictive tool which will enable Customer to obtain a more complete understanding of the chemistry of the water being analyzed. hyd-RO-dose should be used as a supplement to Customer's historical experience and other testing procedures which Customer may utilize. hyd-RO-dose is not intended as a substitute for the exercise of judgment by Customer's employees or consultants.

These terms and conditions state the legally binding understandings between French Creek and Customer relating to the licensing of the System and the performance of services indicated in the French Creek Software Order Form (Order Form). The terms of this Agreement are incorporated by reference into the Order Form.

1. hyd-RO-dose

Customer desires to license hyd-RO-dose as indicated by Customer on the Order Form and more fully described in its accompanying documentation. The System documentation indicates the equipment configurations which may be used to operate hyd-RO-dose , and is hereby incorporated by reference. Customer should specify on the Order Form the number of copies of the System to be licensed under this Agreement.

2. DELIVERY AND SUPPORT

French Creek will ship the number of copies of hyd-RO-dose as indicated on the Order Form as well as System documentation upon French Creek's receipt and acceptance of an executed Order Form and accompanying fees. Delivery will be made at a mutually agreeable time, but no later than thirty (30) days after French Creek has accepted the Order Form. Payment of applicable fees is due upon execution of the Order Form.

hyd-RO-dose is capable of being installed by Customer by following the installation instructions in the documentation. As part of the license fee, French Creek provides 30 days of technical support. Technical support refers to assisting Customer to learn how to operate hyd-RO-dose , but does not include technical assistance in the interpretation of the various indices calculated by hyd-RO-dose . If additional assistance is required, French Creek will use its best efforts to assist Customer and will charge Customer for such services at its then current consulting charges.

3. PAYMENT

The fees and payment terms for the System and services are set forth in the Order Form.

Customer shall be responsible for the payment of any and all taxes or amounts paid in lieu thereof, however designated, levied or based on the System license granted hereunder or upon the services to be rendered or otherwise on account of this Agreement, exclusive only of taxes based on French Creek's net income.

French Creek reserves the right to terminate the System license for failure to pay related license fees or taxes, and/or to terminate any service for failure to pay related service fees or taxes, as stated in the Order Form.

4. CONDITIONS TO SYSTEM LICENSE

French Creek hereby grants Customer a license to operate the System, subject to the terms and conditions of this Agreement. The hyd-RO-dose license is a non-exclusive, non-transferable right to use the System. Failure to abide by any of the conditions stated in this Agreement may result in termination of the license granted in this Agreement.

The hyd-RO-dose license is subject to the following conditions:

(a) Customer acknowledges that the software and other technical data licensed hereunder are subject to export controls imposed on Customer and French Creek by the provisions of the United States Export Administration Act of 1979, as amended, and that the software is exported under a General Export License, designation GTDR, and that the documentation is exported under a General License, designation GTDA. Customer certifies to French Creek that neither the technical data, (in the form of software or manuals), nor the direct product thereof is intended to be shipped, either directly, or indirectly, to Country Groups Q,S,W,Y, or Z, nor Afghanistan or the Peoples' Republic of China, without further compliance with the Validated License requirements of the Office of Export Administration, United States Department of Commerce. Customer agrees to use this technical data only at authorized destinations, and Customer will not knowingly permit exportation or transshipment in violation of the above law and regulations thereunder.

Customer agrees to indemnify and hold French Creek harmless from any and all costs, damages, fines, or other expenses incurred by French Creek by reason of Customer's violation of these representations of Customer.

(b) Each copy of the System may only be used by Customer on one equipment work station as defined in the System documentation at any one time. Customer may not use or allow use of the System in any time-sharing or service bureau arrangement, or with any interactive cable system or local area network. Customer may only use the System for its own internal business or in servicing the business requirements of its clients for whom Customer performs services.

(c) Customer shall not release, or allow the release of, the System or its related documentation, in any form to any third party, except to Customer's employees who are directly concerned with the licensed use of the System, except as otherwise specifically stated herein.

(d) Customer shall not copy the System, except for purposes of normal backup and testing, without the prior written consent of French Creek. In the event that Customer copies the System or its accompanying documentation as stated herein, Customer agrees to also copy French Creek's copyright notices and/or other proprietary notices in the same manner, location and method of presentation as existed in the materials supplied by French Creek to Customer.

(e) Other than as stated in this Agreement, Customer understands and agrees that it has no right, title or interest in the System, and agrees that it shall not attempt at any time to transfer its rights to use the System without the prior written consent of French Creek. Customer agrees that it will not use System, except as stated herein. Customer further agrees that it will not modify, decompile or

disassemble the System, nor shall Customer incorporate the System into any updated or derivative work without the prior written consent of French Creek. For purposes of this Agreement, the term, updated or derivative work , is intended to refer to the use of the System, either in whole or in part, in the development of some other system of work, whether or not such other system or work is operated by computer or otherwise. The term, updated or derivative work , is not intended to refer to any interfaces or other methods of access to the System.

5. WARRANTY

For a period of thirty days following Customer's receipt of the System, French Creek warrants that Customer shall have the right to return the System and to receive a full refund of related license and initial maintenance fees (exclusive of travel, living and out-of-pocket expenses), if the System fails to operate substantially in accordance with the System documentation.

EXCEPT AS OTHERWISE STATED HEREIN, FRENCH CREEK MAKES NO REPRESENTATION OR WARRANTY (EXPRESS, IMPLIED OR STATUTORY) CONCERNING THE SYSTEM OR SERVICES PROVIDED HEREUNDER. FRENCH CREEK SPECIFICALLY DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE FOR SUCH SYSTEM OR SERVICE. CUSTOMER UNDERSTANDS AND AGREES THAT THE SYSTEM IS LICENSED STRICTLY ON AN AS IS BASIS.

The terms and conditions of this section shall survive any termination of this Agreement.

6. INDEMNITY

French Creek warrants that it has all necessary rights to license the System to Customer. French Creek agrees to indemnify, defend and hold Customer harmless for breach of such warranty, provided that, Customer gives French Creek prompt notice of a claim alleging such breach and, provided further, that French Creek shall have full authority to defend, settle or compromise such claim. If the use of the System provided hereunder is prohibited based on a claim of infringement of another party's rights, then French Creek shall either:

- (a) procure the right for Customer to use such licensed System;
- (b) modify such portion of the System to become non-infringing, provided that such modification does not adversely affect Customer's intended use of the System as contemplated hereunder;
- (c) replace the infringing portions of the System with equally suitable, compatible and functionally equivalent non-infringing programs and/or other materials at no additional charge to Customer;
- (d) if none of the above are commercially practicable, then Customer shall terminate its use of the licensed System and accept from French Creek as compensation therefor all license fees paid hereunder less an amount equal to such license fees, divided by 60, multiplied by the number of months of Customer's use of the System, commencing with the date of System delivery.

This warranty and indemnity shall not apply if Customer is in material breach of this Agreement and such breach gave rise to French Creek's liability hereunder. Similarly, this warranty and indemnity shall not apply if the basis for the infringement claim is due to the System being used in conjunction with software not supplied by French Creek hereunder, or which differs in any way from the software or equipment configuration specified in the documentation for use with the System.

This section states French Creek's entire liability concerning allegations that French Creek lacked the right to license the System hereunder. The terms and conditions of this section shall survive any termination of this Agreement.

7. CONFIDENTIAL INFORMATION

Customer acknowledges that the System and accompanying documentation constitute valuable and proprietary property of French Creek. Customer understands and agrees that French Creek may suffer irreparable harm in the event of any unauthorized disclosure of any portion of the System and/or its accompanying documentation which may substantially diminish the value of such System and documentation to French Creek. Therefore, Customer agrees not to disclose any portion of the System or accompanying documentation without the prior written consent of French Creek, except that Customer may disclose such materials (a) to employees of Customer who have a need to be familiar with the operation of the System or its accompanying documentation; (b) to any governmental agency with supervisory authority over Customer, or pursuant to compulsory legal process; or (c) to others in a strict confidential relationship with Customer. In this regard, Customer shall take all steps as are necessary or appropriate to fulfill this obligation.

In the event that Customer materially breaches its obligations under this section, Customer understands and agrees that French Creek has the right to terminate this Agreement upon written notification to Customer. Customer further agrees upon such termination to return to French Creek the original and all copies of the licensed System and related documentation. Furthermore, Customer acknowledges that French Creek shall be entitled to an injunction prohibiting the use and further disclosure of such licensed System and materials, and further entitled to money damages resulting from such unauthorized disclosure. The rights and remedies set forth herein are not exclusive and are in addition to any other rights and remedies provided by law, and the exercise of one right shall not preclude the exercise of any other right stated herein.

The terms and conditions of this section shall survive any termination of this Agreement.

8. MAINTENANCE

Customer may elect to have French Creek perform maintenance services for the System by so indicating on the Order Form. Maintenance services will commence upon Customer's execution of the Order Form and French Creek's receipt of the appropriate maintenance fee. Maintenance services will be provided for an initial term of one year, and will renew for additional one year terms unless either party gives 60 days prior written notice of its intention to terminate such services. Fees for renewal terms of maintenance services will be calculated as a percentage of the then current license fee for the System at time of renewal.

Under maintenance, French Creek will provide Customer with periodic releases of the System that will include minor enhancements as well as modifications to keep the System operating in accordance with its accompanying documentation. Prior releases of the System will be supported for three (3) months after a new release becomes available to Customer.

Support services under maintenance include telephone consultation and other reasonable services necessary to keep the System (as supplied by French Creek) performing in accordance with its documentation. These services will be performed during French Creek's normal East Coast (US) business hours. Ordinarily, French Creek will be able to correct the problem over the telephone. However, if requested by French Creek, Customer will document the circumstances giving rise to such problem and provide such explanation to French Creek in writing. If French Creek is unable to

correct the problem within 48 business hours of receipt of such written explanation and such problem prevents normal operation of the System consistent with its documentation, French Creek will provide Customer with another copy of the System to help resolve the problem. If it is determined that the problem was caused by Customer or that Customer failed to properly follow French Creek's directions, French Creek shall be entitled to be reimbursed for all out-of-pocket expenses, plus consulting time at French Creek's then current billing rates.

If Customer declines maintenance at time of licensing or fails to continue maintenance services, and then elects to begin or resume maintenance coverage, Customer shall pay to French Creek all maintenance fees that would have been payable to French Creek if Customer had been or remained on maintenance plus an additional 10% reinstatement fee.

Customer may also request that French Creek provide other future modifications and enhancements under a separate agreement for such services.

The terms and conditions of this section state French Creek's entire responsibility to provide maintenance services hereunder.

9. UNINTENDED USE

Customer agrees that it will use the System as supplied by French Creek only for the purposes and in the manner set forth in this Agreement and accompanying documentation. In the event that Customer breaches its responsibility under this section or if Customer is not using the System in accordance with its documentation, then French Creek will have no further obligation to provide technical support or maintenance services hereunder and Customer shall not be entitled to a refund of any amount paid to French Creek. In certain circumstances, French Creek may also have the right to terminate this Agreement.

10. LIMITATION OF LIABILITY

French Creek's liability during the 30 day period following delivery of the System shall be limited to attempting to repair any System error condition, or to accept return of the System and refund to Customer all related license and initial maintenance fees, exclusive of travel, living and out-of-pocket expenses, paid to French Creek on account of this Agreement. Thereafter, French Creek's liability to Customer shall not exceed the amount of license fees paid to French Creek on account of the System. French Creek shall have no liability to Customer for damages resulting from causes beyond French Creek's reasonable control.

IN NO EVENT WILL FRENCH CREEK BE LIABLE FOR ANY SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES (INCLUDING LOSS OF PROFITS OR GOODWILL) ARISING FROM OR IN CONNECTION WITH THE SYSTEM OR SERVICES PROVIDED UNDER THIS AGREEMENT, EVEN IF FRENCH CREEK IS ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

THIS SECTION STATES CUSTOMER'S EXCLUSIVE REMEDIES UNDER THIS AGREEMENT. THIS SECTION SHALL SURVIVE ANY TERMINATION OF THIS AGREEMENT.

11. TERM AND TERMINATION

The license granted in this Agreement is for a term of twenty (20) years, or until sooner terminated as stated herein. Upon termination, Customer shall return to French Creek the original and all copies of the licensed System and related documentation, or certify in writing to French Creek the

destruction of such materials. French Creek reserves the right to terminate any service provided hereunder as stated herein or in the Order Form.

12. GENERAL

(a) AMENDMENT: No amendment or supplement to this Agreement shall be binding unless consented to in writing and signed by both parties, provided that such consent shall not be unreasonably withheld. The party requesting any consent under this Agreement shall reimburse the other party for any expenses, including attorneys' fees, which result from the request for consent.

(b) ASSIGNMENT: Neither party may assign, sub-license, sub-lease, lend, rent or otherwise transfer this Agreement or the rights granted hereunder to any person, whether by operation of law or otherwise, without the other party's prior written consent, which consent shall not be unreasonably denied, PROVIDED HOWEVER, that no consent shall be required for any assignment or transfer Pursuant to any merger, consolidation or reorganization to which either Customer or French Creek is a party. This Agreement shall bind and inure to the benefit of any such successor or assign. The license granted hereunder shall not be assigned or assignable in any proceeding involving the liquidation of Customer.

(c) RELATIONSHIP OF THE PARTIES: It is clearly understood between the parties that at all times during this Agreement that the relationship between French Creek and Customer is solely as independent contractors and in no other capacity. The parties agree that there are no intended or incidental third party beneficiaries of this Agreement.

(d) COST OF ENFORCEMENT: If either party is required to engage in legal proceedings to enforce the obligations of the other, in law or in equity, the prevailing party shall be entitled to reasonable attorneys' fees and all related necessary and reasonable costs and expenses.

(e) SEVERABILITY: In the event that any one or more of the provisions of this Agreement shall for any reason be held to be invalid, illegal or unenforceable, the remaining provisions of this Agreement shall be unimpaired, and the invalid, illegal or unenforceable provisions shall be replaced by a mutually acceptable provisions, which being valid and legally enforceable, comes closest to the intention of the parties underlying the invalid, illegal or unenforceable provision. If this Agreement or any provisions hereof are held to be invalid, illegal or unenforceable under the laws of a particular jurisdiction, it is the intention of the parties that all of the provisions of this Agreement shall remain in full force and effect in all other states and jurisdictions.

(f) ATTACHMENTS: The terms and conditions of the attachments and Exhibits to this Agreement are incorporated herein by this reference and shall constitute a part of this Agreement as if fully set forth herein.

(g) HEADINGS: The section headings in this Agreement are for the purposes of reference only and shall not limit or otherwise affect any of the terms hereof.

(h) AUTHORITY: Both parties warrant that all approvals necessary for the execution of this Agreement have been obtained, and that the individuals signing the Order Form on behalf of their respective parties have full authority to do so.

(i) NOTICES: Unless otherwise provided herein, all notices or other communications under this Agreement must be in writing and signed by a duly authorized representative of the party giving such notice, or such other persons as either party shall specify in a written notice to the other. All such notices shall be deemed given and received when delivered by hand, or placed in the mails addressed to the other party, first class registered mail, postage prepaid, at the addresses indicated following the signatures of the parties on the Order Form or such other addresses as may be specified in writing.

(j) ENTIRE AGREEMENT: The terms and conditions stated herein constitute the entire and exclusive agreement between the parties for the System, and no other statements, unless agreed to in writing, shall be binding upon the parties. No statement of any marketing representative shall be binding on French Creek, unless set forth in writing and agreed to by French Creek. This Agreement shall be effective only after its acceptance by French Creek at its offices in Pennsylvania.

(k) GOVERNING LAW: This Agreement shall be governed and construed in accordance with the laws of the Commonwealth of Pennsylvania.

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane	Vary pH Graph vs pH 3D Profile Select Parameters			EDIT CORRELATION Edit Coefficients Browse Correlations		

Navigate through hyd-RO-dose using the familiar Windows menu interface. The program was designed to flow in the same order that you might evaluate a system. The FILES pulldown menus handle housekeeping chores such as storing and retrieving files, clearing the workspace with the **New** command, and exiting with the **Quit** command.

The **INPUT** pulldown handles the input of **Raw Water Chemistry**, and R.O. System **Specifications** including Membrane selection.

Once you have completed inputting the basic survey information, move on to "What-if" modelling in the **"WHAT-IF SCENARIOS"** pulldown menu. Use the **Select Parameters** input form to specify the Recovery Rate range you wish to model, to select pH control agents and the Control point (Feed Water pH or Concentrate). Inhibitors can be modelled by selecting in the **ANTISCALANT Select Product** module.

Advanced users with Formulator or Laboratory Editions can create their own scale inhibitor products using the **Input Product** form in the **ANTISCALANT** pulldown menu.

Researchers with the Laboratory Edition can use the **LABORATORY** pulldown selections to convert their laboratory and field inhibitor performance data into mathematical models.

HOT KEY COMBINATIONS

F1	Module level Help
ALT H	Field level Help
ALT P	Print the graph or report displayed
ALT F	Save graph displayed to PCX, BMP, or TIF file
ALT E	Export displayed 3D graph data as an ASCII file.
ALT G	Select Graphs
ALT U	Select Input Units
ALT T	Toggles graph between Treated & Untreated Color Coding.
ALT L	Toggles 3D Graph Label Display On and Off
PgUp PgDn	Page through 3D graphs when one of the Convenient Groups is selected.

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New	CHEMISTRY	Concentrate	Print Raw Water	Select Product	ANALYSIS INPUT	Choose Graphs	Technical Manual
Open File	Raw Water Analysis	Vary Recovery	Print System Specs	Input Product	Input Lab Data	Input Units	
Save File	Input pH Curve	Graph vs Recovery	Print Summary			Print Mode	
Save File As	SYSTEM PARAMETERS	Vary pH	Print Recovery Profile		EDIT CORRELATION	3D Graph Types	
Printer Setup	Specifications	Graph vs pH	Print pH Profile		Edit Coefficients	CO3 Calc's	
What's Stored	Membrane	3D Profile	Print All		Browse Correlations	Constant Values	
About hyd-RO-dose		Select Parameters				Output Size On Screen	
Quit							

SELECTION PURPOSE: The **New** selection, in the **FILES** pulldown menu, allows you to enter a new analysis without the possibility of “carryover” values from the previous water evaluated. It allows you to start afresh without exiting the program and starting over.

WHEN SHOULD IT BE USED? Select **New** when you have completed the evaluation of a water, saved the results if desired, and are ready to enter a new water analysis for evaluation. The **New** selection assures that the new analysis is entered on a “clean slate.”

WHAT DOES IT DO? The **New** module reinitializes all values to the startup, default values. When the **New** module is executed, it resets all flags in the program. For example, when a raw water is entered into the program, a flag is set that tells other modules that a valid raw water analysis has been entered. This allows the other modules that require a raw water analysis that this prerequisite has been completed. All data for an unsaved analysis is lost when the **New** option is executed.

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New	CHEMISTRY	Concentrate	Print Raw Water	Select Product	ANALYSIS INPUT	Choose Graphs	Technical Manual
Open File	Raw Water Analysis	Vary Recovery	Print System Specs	Input Product	Input Lab Data	Input Units	
Save File	Input pH Curve	Graph vs Recovery	Print Summary		EDIT CORRELATION	Print Mode	
Save File As	SYSTEM PARAMETERS	Vary pH	Print Recovery Profile		Edit Coefficients	3D Graph Types	
Printer Setup	Specifications	Graph vs pH	Print pH Profile		Browse Correlations	CO3 Calc's	
What's Stored	Membrane	3D Profile	Print All			Constant Values	
About hyd-RO-dose		Select Parameters				Output Size On Screen	
Quit							

SELECTION PURPOSE: The **Open File** selection, in the **FILES** pulldown menu, allows you to restore a previously evaluated water analysis and all calculations completed prior to the work being saved in a file. All program flags are reset to the state when the work was saved.

WHEN SHOULD IT BE USED? Select **Open File** when you wish to review the results of a previously completed water evaluation. Restore previously saved work when you wish to prepare further graphs, or evaluate further parameters using the **WHAT-IF SCENARIOS** (e.g. further recovery rate for a water, or a broader pH range).

WHAT DOES IT DO? The **Open File** module loads all input and calculated values from a previously saved disk file. Parameters in effect when the work was saved are also loaded, including graph choices.

WHAT DO YOU NEED? You need the name of the file where previous work was stored, as well as the disk drive and directory and/or subdirectory information. Unless you specify otherwise, the program automatically saves files on the disk drive and directory from which the program was executed.

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
Save File As Printer Setup What's Stored About hyd-RO-dose Quit	SYSTEM PARAMETERS Specifications Membrane	Vary pH Graph vs pH 3D Profile Select Parameters			EDIT CORRELATION Edit Coefficients Browse Correlations		

SELECTION PURPOSE: The **Save File** selection, in the **FILES** pulldown menu, allows you to save a water analysis and all calculations completed in a hard or floppy disk file. All program flags are saved in their current state so that modules with prerequisites will be aware of what work has been completed. (e.g. a raw water analysis must be entered prior to running the **Concentrate** module or there would be nothing but garbage numbers to concentrate!)

WHEN SHOULD IT BE USED? Select **Save File** when you wish to save work completed in the current .HYD file for later use or review. Save an analysis in this manner also allows you to make minor modifications to input analysis without having to totally re-enter all parameters. It can also save time and date re-entry if you wish to prepare further graphs, or evaluate further parameters using the **WHAT-IF SCENARIOS** (e.g. further recovery rates, or a broader pH).

WHAT DOES IT DO? The **Save File** module saves all input and calculated values to a the current .HYD disk file. Parameters in effect when the work was saved are also saved, including graph choices. Each file saved should have the .HYD extension (e.g. EXAMPLE.HYD) and will require between 56K and 60K bytes of available disk space.

WHAT DO YOU NEED? You need to previously have saved the workspace to a file. The program automatically saves files on the disk drive and directory from which the program was executed.

PREREQUISITES: This selection will not be active unless you have previously saved the workspace using the **Save File As** module).

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New	CHEMISTRY	Concentrate	Print Raw Water	Select Product	ANALYSIS INPUT	Choose Graphs	Technical Manual
Open File	Raw Water Analysis	Vary Recovery	Print System Specs	Input Product	Input Lab Data	Input Units	
Save File		Graph vs Recovery	Print Summary			Print Mode	
Save File As	SYSTEM PARAMETERS	Vary pH	Print Recovery Profile		EDIT CORRELATION	3D Graph Types	
Printer Setup	Specifications	Graph vs pH	Print pH Profile		Edit Coefficients	CO3 Calc's	
What's Stored	Membrane	3D Profile	Print All		Browse Correlations	Constant Values	
About hyd-RO-dose		Select Parameters				Output Size On Screen	
Quit							

SELECTION PURPOSE: The **Save File As** selection, in the **FILES** pulldown menu, allows you to save a water analysis and all calculations completed in a hard or floppy disk file. All program flags are saved in their current state so that modules with prerequisites will be aware of what work has been completed. (e.g. a raw water analysis must be entered prior to running the **Concentrate** module or there would be nothing but garbage numbers to concentrate!)

WHEN SHOULD IT BE USED? Select **Save File As** when you wish to save work completed for later use or review. Save an analysis in this manner also allows you to make minor modifications to input analysis without having to totally re-enter all parameters. It can also save time and date re-entry if you wish to prepare further graphs, or evaluate further parameters using the **WHAT-IF SCENARIOS** (e.g. further recovery rates, or a broader pH).

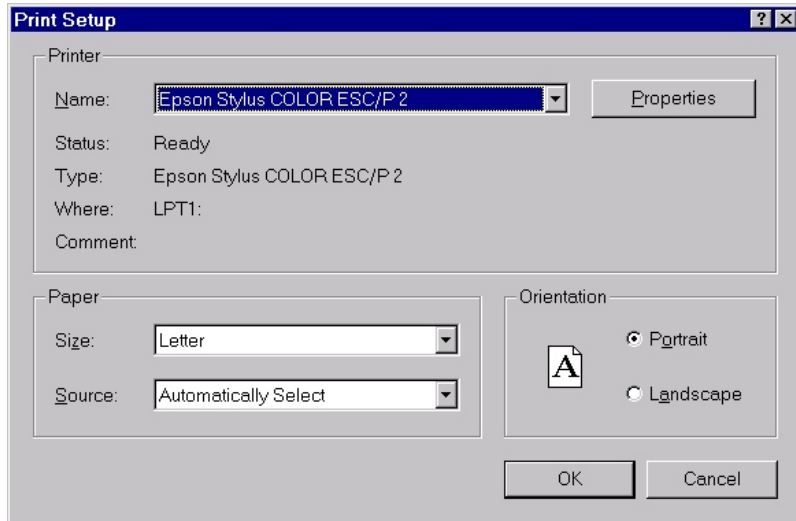
WHAT DOES IT DO? The **Save File As** module saves all input and calculated values to a disk file. Parameters in effect when the work was saved are also saved, including graph choices. Each file saved should have the .HYD extension (e.g. EXAMPLE.HYD) and will require between 56K and 60K bytes of available disk space.

WHAT DO YOU NEED? You need a unique name for the file as well as the disk drive and directory and/or subdirectory information. Unless you specify otherwise, the program automatically saves files on the disk drive and directory from which the program was executed.

PREREQUISITES: This selection will not be active unless sufficient information has been entered (e.g. a minimum of the **Raw Water Analysis** must be run for the **Save File As** selection to be active).

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New	CHEMISTRY	Concentrate	Print Raw Water	Select Product	ANALYSIS INPUT	Choose Graphs	Technical Manual
Open File	Raw Water Analysis	Vary Recovery	Print System Specs	Input Product	Input Lab Data	Input Units	
Save File	Input pH Curve	Graph vs Recovery	Print Summary			Print Mode	
Save File As		Vary pH	Print Recovery Profile		EDIT CORRELATION	3D Graph Types	
Printer Setup	SYSTEM PARAMETERS	Graph vs pH	Print pH Profile		Edit Coefficients	CO3 Calc's	
What's Stored	Specifications	3D Profile	Print All		Browse Correlations	Constant Values	
About hyd-RO-dose	Membrane	Select Parameters				Output Size On Screen	
Quit							



SELECTION PURPOSE: The **Printer Setup** selection, in the **FILES** pulldown menu, accesses the Windows setup dialog box for your currently selected printer.

WHEN SHOULD IT BE USED? Select **Printer Setup** when you wish to select a different printer from the list of those currently installed in Windows, when you wish to change printer resolution, or other properties accessible by Windows.

WHAT DOES IT DO? The **Printer Setup** module calls the Windows printer setup dialog.

WHAT DO YOU NEED? You need to have a printer installed in Windows.

NOTE: THE DIALOG DISPLAYED WILL BE FOR YOUR CURRENTLY SELECTED DEFAULT PRINTER. CHANGING THE PRINTER FROM WITHIN hyd-RO-dose WILL ONLY AFFECT PRINTING FROM hyd-RO-dose. IT WILL NOT CHANGE YOUR DEFAULT PRINTER.

The dialog on the left is an example, and will vary with each printer and version of the Windows Operating System.

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New	CHEMISTRY	Concentrate	Print Raw Water	Select Product	ANALYSIS INPUT	Choose Graphs	Technical Manual
Open File	Raw Water Analysis	Vary Recovery	Print System Specs	Input Product	Input Lab Data	Input Units	
Save File	Input pH Curve	Graph vs Recovery	Print Summary			Print Mode	
Save File As	SYSTEM PARAMETERS	Vary pH	Print Recovery Profile		EDIT CORRELATION	3D Graph Types	
Printer Setup	Specifications	Graph vs pH	Print pH Profile		Edit Coefficients	CO3 Calc's	
What's Stored	Membrane	3D Profile	Print All		Browse Correlations	Constant Values	
Quit		Select Parameters				Output Size On Screen	

WORK FILE BROWSE & DELETE

f:\hydro*.hyd Date Time ID #

NEWTST.HYD

TESTFEED.HYD

TST.HYD

TSTBR.HYD

Sample Description

System Type Version #

f:\hydro

SELECTION PURPOSE: The *What's Stored* selection, in the **FILES** pulldown menu, allows you to quickly scan the work files previously saved by the program. The ID#, analysis description fields, comments, and file type are displayed for each filename selected.

WHEN SHOULD IT BE USED? Select *What's Stored* when you can't quite remember the name of a file in which you saved some critical work, or when you are about to perform housekeeping by deleting old, never to be used again files, and aren't sure What's Stored.

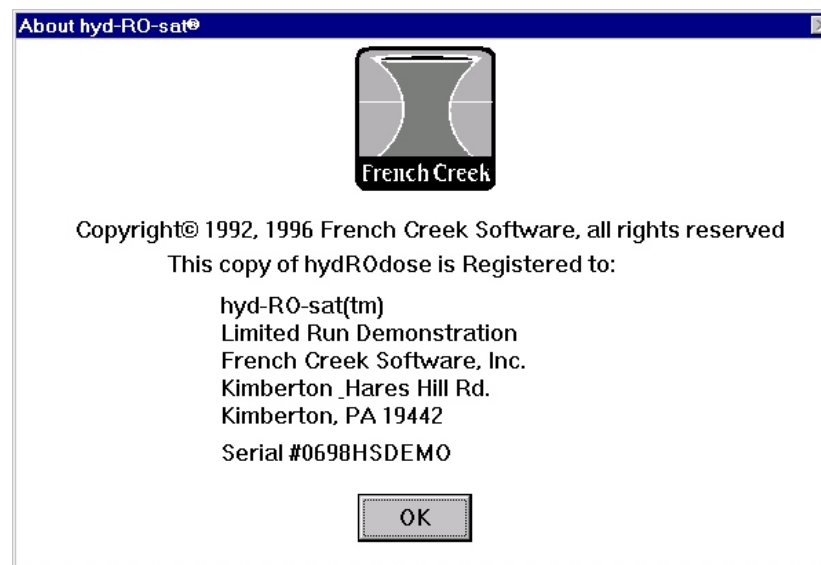
WHAT DOES IT DO? The *What's Stored* module displays the names of all files (*.HYD) which were previously saved using the **Save File** or **Save File As** module. Filenames are displayed in a scrolling, vertical menu for selection. The *What's Stored* module opens each file selected and quickly displays descriptive information about the file.

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New	CHEMISTRY	Concentrate	Print Raw Water	Select Product	ANALYSIS INPUT	Choose Graphs	Technical Manual
Open File	Raw Water Analysis	Vary Recovery	Print System Specs	Input Product	Input Lab Data	Input Units	
Save File	Input pH Curve	Graph vs Recovery	Print Summary		EDIT CORRELATION	Print Mode	
Save File As	SYSTEM PARAMETERS	Vary pH	Print Recovery Profile		Edit Coefficients	3D Graph Types	
Printer Setup	Specifications	Graph vs pH	Print pH Profile		Browse Correlations	CO3 Calc's	
What's Stored	Membrane	3D Profile	Print All			Constant Values	
About hyd-RO-dose		Select Parameters				Output Size On Screen	
Quit							

SELECTION PURPOSE: The **About hyd-RO-dose** selection, in the **FILES** pulldown menu, displays the registration and copyright information for the program.

WHEN SHOULD IT BE USED? Select **About hyd-RO-dose** when you wish to verify program registration details. This information may be needed when you call technical support for assistance.



hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
Quit	SYSTEM PARAMETERS Specifications Membrane	Vary pH Graph vs pH 3D Profile Select Parameters			EDIT CORRELATION Edit Coefficients Browse Correlations		

SELECTION PURPOSE: The **Quit** selection, in the **FILES** pulldown menu, does just that. It exits the program and returns control to the Windows Operating System.

WARNING: Make sure all files are saved before you **Quit**. Once you exit the program all unsaved data is lost.

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve SYSTEM PARAMETERS Specifications Membrane	Concentrate Vary Recovery Graph vs Recovery Vary pH Graph vs pH 3D Profile Select Parameters	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data EDIT CORRELATION Edit Coefficients Browse Correlations	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual

Press the button by either date input field to display a calander to pick the date.

SELECTION PURPOSE: The **Raw Water Analysis** module, in the **INPUT** pulldown menu, generates a form on the screen for input of raw water analyses. Other relevant modules can be called from this input form, such as the **Input Units** module, for changing analytical reporting units, and the **Set Constant Values** module, for setting a constant phosphate or silica in the water.

WHEN SHOULD IT BE USED? Select **Raw Water Analysis** to enter a raw water analysis and calculate the indicators of scale and corrosivity potential. This module is also a prerequisite for running the **WHAT-IF SCENARIOS**, including **Concentrate**, **Profile vs Recovery**, **Profile vs pH**, and **3D Graph**.

WHAT DOES IT DO? The Raw Water Analysis module accepts water chemistry input via a user friendly form, and runs simple validation tests on the values entered to assure that they are in a reasonable range (e.g. a pH of -1 is unacceptable to the validation routines). Calculated values are displayed after entry is complete.

PREREQUISITES: There are no prerequisites for the **Raw Water Analysis** module. You might wish to run the **Input Units** module from the **PREFERENCES** pulldown menu, or by clicking on the **Change Units** button at the bottom of the form, if analytical units other than mg/l or alkalinities in a form other than "M" and "P" are to be entered. You should make sure that a printer is selected prior to printing the calculated values.

HINTS: Don't know the date? Press the button to the right of either date input field to display a calendar. Need to change the analytical units (e.g. from Ca as Ca to Ca as CaCO3)? Press the **Change Units** button.

Raw Water Chemistry Input

Sample Date	<input type="text" value="09-02-1997"/>	Time	<input type="text" value="16:48"/>	ID#	<input type="text" value="0"/>	Report Date	<input type="text" value="09-02-1997"/>
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Sample Description

<input type="text" value="hyd-RO-dose"/>	<input type="text" value="French Creek"/>
<input type="text" value="Example File"/>	<input type="text" value="Kimberton, PA 19442"/>

Calcium (as CaCO3)	<input type="text" value="111."/>	Iron (as Fe)	<input type="text" value="1.e-002"/>	Hydrogen sulfide (as H2S)	<input type="text" value="0."/>
Magnesium (as CaCO3)	<input type="text" value="23."/>	Ammonia (as NH3)	<input type="text" value="0."/>	Silica (as SiO2)	<input type="text" value="7."/>
Barium (as CaCO3)	<input type="text" value="0."/>	Aluminum (as Al)	<input type="text" value="0."/>	Phosphate (as PO4)	<input type="text" value="0.1"/>
Strontium (as CaCO3)	<input type="text" value="0."/>	Boron (as B)	<input type="text" value="0."/>	Fluoride (as F)	<input type="text" value="0.5"/>
Sodium (as Na)	<input type="text" value="53."/>	Chloride (as Cl)	<input type="text" value="36."/>	Nitrate (as NO3)	<input type="text" value="0."/>
Potassium (as K)	<input type="text" value="1."/>	Sulfate (as SO4)	<input type="text" value="75.343"/>	Temperature (as °F)	<input type="text" value="77."/>
Lithium (as Li)	<input type="text" value="0."/>	Aciditv (as CaCO3)	<input type="text" value="0."/>	Density (mg/L)	<input type="text" value="1."/>
pH(raw) (pH Units)	<input type="text" value="7.6"/>	M Alkalinity (as CaCO3)	<input type="text" value="120."/>	Pressure (Atm.)	<input type="text" value="1."/>
Residence time (Seconds)	<input type="text" value="1500."/>	P Alkalinity (as CaCO3)	<input type="text" value="0."/>	Silt Densitv Index	<input type="text" value="0."/>

Comments:

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY	Concentrate	Print Raw Water	Select Product	ANALYSIS INPUT	Choose Graphs	Technical Manual
	Raw Water Analysis	Vary Recovery	Print System Specs	Input Product	Input Lab Data	Input Units	
	Input pH Curve	Graph vs Recovery	Print Summary		EDIT CORRELATION	Print Mode	
	SYSTEM PARAMETERS	Vary pH	Print Recovery Profile		Edit Coefficients	3D Graph Types	
	Specifications	Graph vs pH	Print pH Profile		Browse Correlations	CO3 Calc's	
	Membrane	3D Profile	Print All			Constant Values	
		Select Parameters				Output Size On Screen	

	M Alkalinity	Actual	Predicted pH		M Alkalinity	Actual	Predicted pH
1)	<input type="text" value="300."/>	<input type="text" value="8.55"/>	<input type="text" value="8.524"/>	6)	<input type="text" value="0."/>	<input type="text" value="0."/>	<input type="text" value="0."/>
2)	<input type="text" value="120."/>	<input type="text" value="7.9"/>	<input type="text" value="7.931"/>	7)	<input type="text" value="0."/>	<input type="text" value="0."/>	<input type="text" value="0."/>
3)	<input type="text" value="40."/>	<input type="text" value="7.2"/>	<input type="text" value="7.221"/>	8)	<input type="text" value="0."/>	<input type="text" value="0."/>	<input type="text" value="0."/>
4)	<input type="text" value="20."/>	<input type="text" value="6.8"/>	<input type="text" value="6.773"/>	9)	<input type="text" value="0."/>	<input type="text" value="0."/>	<input type="text" value="0."/>
5)	<input type="text" value="0."/>	<input type="text" value="0."/>	<input type="text" value="0."/>	10)	<input type="text" value="0."/>	<input type="text" value="0."/>	<input type="text" value="0."/>

SELECTION PURPOSE: The **Input pH Curve** module, in the **INPUT CHEMISTRY** pulldown menu, accepts a user defined pH-Alkalinity relationship for use in predicting the pH of concentrated water from alkalinity in other modules. Values entered are converted to a mathematical model which can be selected as the pH-Alkalinity prediction method..

WHEN SHOULD IT BE USED? Select **Input pH Curve** to replace the default pH-Alkalinity curve with an empirical relationship you feel is more applicable to the system under study. **NOTE:** Once input, you must select the User Defined Curve method for pH prediction in the Select Parameters module.

WHAT DOES IT DO? The **Input pH Curve** module accepts pH-"M" Alkalinity pairs and converts them to a formula for use by other modules which predict chemistry and pH. Simple curve fit statistics are displayed as well as a simple Actual - Predicted comparison. You can also display a pH-Alkalinity graph by pressing the **Graph** button.

WHAT DO YOU NEED? A minimum of five (5) pH-"M" Alkalinity pairs should be on hand for entry. The input form will accept a maximum of ten (10) pairs. Select pairs that cover the alkalinity range expected. Extrapolate if you must! Unusual results may be encountered if your model was developed from data in an alkalinity range of 20 to 100 mg/l as CaCO₃ and you attempt to evaluate a pH at an alkalinity of 400! If your data does not cover a broad enough range to encompass your **WHAT-IF's**, please use the default pH-Alkalinity curves.

TRICK - the program will accept a single point. If you enter a single pH - Alkalinity pair, the model will use the slope of the Default (Kunz) curve and translate the intercept based upon the value entered.

PREREQUISITES: There are no prerequisites for the **Input pH Curve** module.

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery Vary pH Graph vs pH 3D Profile Select Parameters	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane				EDIT CORRELATION Edit Coefficients Browse Correlations		

PRESS THE MEMBRANE BUTTON TO SELECT THE SPECIFIC ION REJECTION PROFILE FOR A STANDARD MEMBRANE.

SELECTION PURPOSE: The **Specifications** selection provides the Flow and Recovery data used by the **Concentrate** module. You can also select membrane specific ion rejection profiles from those on file.

HINTS: 1) If the membrane profile you need is not on file, enter the spec's yourself using the **Membrane** module in the **INPUT** pulldown menu. 2) Change flow units in the **Input Units** module.

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery Vary pH Graph vs pH 3D Profile Select Parameters	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane				EDIT CORRELATION Edit Coefficients Browse Correlations		

SELECTION PURPOSE: The **Membrane Specifications** selection allows you to enter custom membrane specific ion rejection profiles and save them to file.

HINTS: 1) Enter the values on a 0.0 to 1.0 basis.

2) The membrane file name must have the extension .MBR

NOTE: This module is only available in the Formulator and Laboratory Editions.

Individual Ion Rejection (Fraction NOT %)

Membrane Type	TriSep A-15	File Name	A15.MBR
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Calcium	0.985	Iron	0.992	CO2	0.09
Magnesium	0.98	Ammonia	0.95	HCO3	0.925
Barium	0.97	Aluminum	0.995	CO3	0.97
Strontium	0.975	Boron	0.96	Hydrogen sulfide	0.07
Sodium	0.96	Chloride	0.97	Silica	0.95
Potassium	0.955	Sulfate	0.985	Phosphate	0.99
Lithium	0.968	Nitrate	0.935	Fluoride	0.94

INITIALIZE TO SAME VALUE

Enter a value between 0.0 and 1.0 in this box, press the MAKE SAME button, and all specific ion rejections will be initialized to this default value.

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane	Vary Recovery Graph vs Recovery Vary pH Graph vs pH 3D Profile Select Parameters			EDIT CORRELATION Edit Coefficients Browse Correlations		

SELECTION PURPOSE: The **Concentrate** module, in the **WHAT-IF SCENARIOS** pulldown menu, models the impact of concentrating a feed water upon indicators of scale and corrosivity potential. The **Concentrate** module will concentrate a raw water with, or without, pH control. Results are displayed on the screen in two overlapping tables. One table outlines the water chemistry as it concentrates from the feed water to the target recovery rate. The second table outlines the calculated indices, saturation levels, and other indicators of scale potential and corrosivity.

WHEN SHOULD IT BE USED? Select **Concentrate** to evaluate indicators of scale and corrosivity potential at the expected operating recovery rate. and to predict the dosage requirements for inhibitor(s) at the operating recovery rate. The **Concentrate** module can also be used to evaluate the impact of pH control points on acid consumption and indicators of scale potential.

WHAT DOES IT DO? The **Concentrate** module evaluates the reject chemistry at the target recovery rate entered in, or calculated, in the **System Specification** module. Other operating conditions such as pH control point, can be selected using the **Select Parameters** module in the same pulldown menu.

PREREQUISITES: The **Raw Water Analysis** module must be run prior to **Concentrate**. The **Input pH Curve** module should be run to input a user defined pH-Alkalinity relationship if you do not wish to use one of the default methods. The **Select Parameters** module should be run to customize the evaluation with respect to pH control options (acid and alkali type), to select the pH estimation method, and to specify whether the pH control point for the target pH is in the Feed Water (feed water pH) or the concentrate (brine pH). An inhibitor product can be selected in the **Select Product** module of the **FORMULARY** pull down menu prior to concentrating, if dosage recommendations are desired.

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY	Concentrate	Print Raw Water	Select Product Input Product	ANALYSIS INPUT	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
	Raw Water Analysis Input pH Curve	Vary Recovery	Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All		EDIT CORRELATION		
	SYSTEM PARAMETERS	Graph vs Recovery Vary pH Graph vs pH 3D Profile Select Parameters			EDIT CORRELATION Edit Coefficients Browse Correlations		
	Specifications Membrane						

SELECTION PURPOSE: The **Vary Recovery** module, in the **WHAT-IF SCENARIOS** pulldown menu, models the impact of concentrating a makeup water upon indicators of scale and corrosivity potential. The **Vary Recovery** module will concentrate a feed water with, or without, pH control. Results are displayed on the screen in two overlapping tables. One table outlines the water chemistry as it concentrates to the target maximum recovery rate. The second table outlines the calculated indices, saturation levels, and other indicators of scale potential and corrosivity versus % Recovery.

WHEN SHOULD IT BE USED? Select **Vary Recovery** to evaluate indicators of scale and corrosivity potential over the expected operating recovery range for the system, and to profile the dosage requirements for inhibitor(s) over this operating range. The **Vary Recovery** module can also be used to evaluate the impact of pH control points on acid consumption and indicators of scale potential.

WHAT DOES IT DO? The Vary Recovery module evaluates the water chemistry at up to seven (7) recovery rates from the minimum selected, to the maximum. Default values are a minimum recovery of 75.0%, maximum of 90.0%, and a 2.5% increment. Other ranges and operating conditions such as pH control point, can be selected using the **Select Parameters** module in the same pulldown menu. The Typical Temperature entered in the **Select Parameters** menu is used for calculations.

PREREQUISITES: The **Raw Water Analysis** module must be run prior to **Vary Recovery**. The **Input pH Curve** module should be run to input a user defined pH-Alkalinity relationship if you do not wish to use the default method. The **Select Parameters** module should be run to customize the evaluation with respect to pH control options, to select the pH estimation method, and to specify a minimum and maximum Recovery Rate and the desired increment between evaluations. A printer should be active for the ALT and P hot key combo. A product should be selected in the **Select Product** module of the **ANTISCALANTS** pull down menu prior to concentrating the water, if dosage recommendations are desired.

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New	CHEMISTRY	Concentrate	Print Raw Water	Select Product	ANALYSIS INPUT	Choose Graphs	Technical Manual
Open File	Raw Water Analysis	Vary Recovery	Print System Specs	Input Product	Input Lab Data	Input Units	
Save File	Input pH Curve	Graph vs Recovery	Print Summary			Print Mode	
Save File As	SYSTEM PARAMETERS	Vary pH	Print Recovery Profile		EDIT CORRELATION	3D Graph Types	
Printer Setup	Specifications	Graph vs pH	Print pH Profile		Edit Coefficients	CO3 Calc's	
What's Stored	Membrane	3D Profile	Print All		Browse Correlations	Constant Values	
About hyd-RO-dose		Select Parameters				Output Size On Screen	
Quit							

SELECTION PURPOSE: The **Graph vs Recovery** module, in the **WHAT-IF SCENARIOS** pulldown menu, models and plots the impact of concentrating a makeup water upon indicators of scale and corrosivity potential. The **Graph vs Recovery** module will use the results of the **Vary Recovery** module, or it will concentrate a feed water with, or without, pH control. Results are displayed on the screen as a two dimensional graph. Each graph plots one line from the tables created by the **Vary Recovery** module. One table outlines the water chemistry as it concentrates to the target maximum recovery rate. The second table outlines the calculated indices, saturation levels, and other indicators of scale potential and corrosivity versus % Recovery.

WHEN SHOULD IT BE USED? Select **Graph vs Recovery** to evaluate and plot indicators of scale and corrosivity potential over the expected operating recovery range for the system, and to profile the dosage requirements for inhibitor(s) over this operating range. The **Graph vs Recovery** module can also be used to evaluate the impact of pH control points on acid consumption and indicators of scale potential.

WHAT DOES IT DO? The **Graph vs Recovery** and **Vary Recovery** modules evaluate the water chemistry at up to seven (7) recovery rates from the minimum selected, to the maximum. Default values are a minimum recovery of 75.0%, maximum of 90.0%, and a 2.5% increment. Other ranges and operating conditions such as pH control point, can be selected using the **Select Parameters** module in the same pulldown menu. The Typical Temperature entered in the **Select Parameters** menu is used for calculations.

PREREQUISITES: The **Raw Water Analysis** module must be run prior to **Vary Recovery**. The **Input pH Curve** module should be run to input a user defined pH-Alkalinity relationship if you do not wish to use the default method. The **Select Parameters** module should be run to customize the evaluation with respect to pH control options, to select the pH estimation method, and to specify a minimum and maximum Recovery Rate and the desired increment between evaluations. A printer should be active for the ALT and P hot key combo. A product should be selected in the **Select Product** module of the **ANTISCALANTS** pull down menu prior to concentrating the water, if dosage recommendations are desired.

HINT: The ALT P hot key combo prints a displayed graph. The ALT F hot key combo exports the graph to your choice of PCX, BMP, or TIF graphical files. Use the menus at the top of the graph for other options such as Gray Scler or Color display, Gray Scale or Color Prints.

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane	Vary pH Graph vs pH 3D Profile Select Parameters			EDIT CORRELATION Edit Coefficients Browse Correlations		

SELECTION PURPOSE: The **Vary pH** module, in the **WHAT-IF SCENARIOS** pulldown menu, models and plots the impact of varying pH upon indicators of scale and corrosivity potential. The **Vary pH** module displays the results of the **Vary pH** module. Results are displayed on the screen in two overlapping tables. One table outlines the water chemistry as pH varies. The second table outlines the calculated indices, saturation levels, and other indicators of scale potential and corrosivity versus pH.

THE pH POINTS WILL REFLECT THE pH AT THE MEASUREMENT POINT SELECTED IN THE **Select Parameters** MODULE. EITHER pH, AS MEASURED IN THE FEED WATER, OR pH AS MEASURED IN THE CONCENTRATE CAN BE SELECTED.

WHEN SHOULD IT BE USED? Select **Vary pH** to evaluate the impact of pH control on indicators of scale and corrosivity potential at the typical recovery rate for the system, and to profile the dosage requirements for inhibitor(s) over this pH range.

WHAT DOES IT DO? The **Vary pH** modules evaluate the water chemistry at up to seven (7) pH points from the minimum selected, to the maximum. Default values are a minimum pH of 6.0, maximum of 7.2 and a 0.2 pH unit increment. Other recovery rates and pH control ranges, can be selected using the **Select Parameters** module in the same pulldown menu. The Typical Temperature entered in the **Select Parameters** menu is used for calculations, as is the Typical Recovery Rate in the System Specification form.

PREREQUISITES: The **Raw Water Analysis** module must be run prior to **Vary pH**. A pH control method MUST be selected in the **Select Parameters** module including an Acid and/or Alkali for pH control. The **Input pH Curve** module should be run to input a user defined pH- Alkalinity relationship if you do not wish to use the default method. The **Select Parameters** module should be run to customize the evaluation with respect to pH control options, to select the pH estimation method, and to specify a minimum and maximum pH control point and the desired increment between evaluations. A printer should be active for the ALT and P hot key combo. A product should be selected in the **Select Product** module of the **ANTISCALANTS** pull down menu prior to concentrating the water, if dosage recommendations are desired.

HINT: The ALT P hot key combo prints a displayed graph. The ALT F hot key combo exports the graph to your choice of PCX, BMP, or TIF graphical files. Use the menus at the top of the graph for other options such as Gray Scl or Color display, Gray Scale or Color Prints.

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery Vary pH	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane	Graph vs pH 3D Profile Select Parameters			EDIT CORRELATION Edit Coefficients Browse Correlations		

SELECTION PURPOSE: The **Graph vs pH** module, in the **WHAT-IF SCENARIOS** pulldown menu, models and plots the impact of varying pH upon indicators of scale and corrosivity potential. The **Graph vs pH** module will use the results of the **Vary pH** module. Results are displayed on the screen as a two dimensional graph. Each graph plots one line from the tables created by the **Vary pH** module. One table outlines the water chemistry as pH varies. The second table outlines the calculated indices, saturation levels, and other indicators of scale potential and corrosivity versus pH.

THE pH POINTS WILL REFLECT THE pH AT THE MEASUREMENT POINT SELECTED IN THE **Select Parameters** MODULE. EITHER pH, AS MEASURED IN THE FEED WATER, OR pH AS MEASURED IN THE CONCENTRATE CAN BE SELECTED.

WHEN SHOULD IT BE USED? Select **Graph vs pH** to evaluate and plot the impact of pH control on indicators of scale and corrosivity potential at the typical recovery rate for the system, and to profile the dosage requirements for inhibitor(s) over this pH range.

WHAT DOES IT DO? The **Graph vs pH** and **Vary pH** modules evaluate the water chemistry at up to seven (7) pH points from the minimum selected, to the maximum. Default values are a minimum pH of 6.0, maximum of 7.2 and a 0.2 pH unit increment. Other recovery rates and pH control ranges, can be selected using the **Select Parameters** module in the same pulldown menu. The Typical Temperature entered in the **Select Parameters** menu is used for calculations, as is the Typical Recovery Rate in the System Specification form.

PREREQUISITES: The **Raw Water Analysis** module must be run prior to **Vary pH**. A pH control method MUST be selected in the **Select Parameters** module including an Acid and/or Alkali for pH control. The **Input pH Curve** module should be run to input a user defined pH- Alkalinity relationship if you do not wish to use the default method. The **Select Parameters** module should be run to customize the evaluation with respect to pH control options, to select the pH estimation method, and to specify a minimum and maximum pH control point and the desired increment between evaluations. A printer should be active for the ALT and P hot key combo. A product should be selected in the **Select Product** module of the **ANTISCALANTS** pull down menu prior to concentrating the water, if dosage recommendations are desired.

HINT: The ALT P hot key combo prints a displayed graph. The ALT F hot key combo exports the graph to your choice of PCX, BMP, or TIF graphical files. Use the menus at the top of the graph for other options such as Gray Scl or Color display, Gray Scale or Color Prints.

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane	Vary pH Graph vs pH 3D Profile Select Parameters			EDIT CORRELATION Edit Coefficients Browse Correlations		

SELECTION PURPOSE: The **3D Profile** module, in the **WHAT-IF SCENARIOS** pull down menu, models the impact of pH and % Recovery upon indicators of scale and corrosivity potential and dosage requirement. Indicator or dosage trends are presented versus both pH and Recovery to provide an in-depth profile of the system.

WHEN SHOULD IT BE USED? Select **3D Profile** to evaluate indicators of scale and corrosivity potential, or dosage requirements, over the expected operating pH and recovery range for the system. Include the minimum and maximum expected pH values and % recovery to assure that foulants are evaluated under the harshest expected conditions. The module is also useful for comparing product dosages over the operating range expected for a system to assure that a treatment can handle the system conditions over its entire pH-recovery range.

WHAT DOES IT DO? The **3D Profile** module evaluates the water chemistry in a seven (7) by seven (7) matrix of pH values and % recovery at the Typical Temperature entered in the Operating Range Specifications section of the **Select Parameters** module. % Recovery and pH are evenly spaced from the minimum to the maximum. Default values are a 6.0 minimum and 7.2 maximum for pH and 75% to 90% for recovery. The 3D graphs generated are color coded from blue (least cause for concern) to red (highest problem potential). Gray scale screens are used for monochrome systems and printers. Display and output options can be selected from the menus at the top of the graph screen. "Hot key" combinations can also be used to select display and output options. The ALT and P hot key combo will print the displayed graph to the currently selected printer. The ALT and F key combo allows you to save a graph being displayed to a PCX, BMP, or TIF file for use in other programs. The ALT and E key combo, or Export Data menu selection, exports the calculated values used to prepare the graph in ASCII format. When Bar Graphs are displayed, the ALT C key combo switches the display to contour plots. When contour plots are displayed, ALT and B switches to the bar graph format.

PREREQUISITES: A **Raw Water Analysis** must be entered prior to running the **3D Profile** module. Operating Range Specifications should have been entered in the **Select Parameters** module. The module will ask you to select graphs from a scrolling vertical menu if none are selected. You can change the graph selection using the **Select Graphs** option from the **PREFERENCES** pull down menu, or by depressing the ALT and G hot key combo. The ALT G combo is active when the main menu is waiting for input. A printer should be active. A product should be selected in the **Select Product** module of the **ANTISCALANT** pull down menu prior to graphing. Graphs can be run successively with different products by alternating between the Select Product and 3D Profile modules. A pH control method and acid and/or alkali must have been selected in the **Select Parameters** module.

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve SYSTEM PARAMETERS Specifications Membrane	Concentrate Vary Recovery Graph vs Recovery Vary pH Graph vs pH 3D Profile Select Parameters	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data EDIT CORRELATION Edit Coefficients Browse Correlations	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual

SELECTION PURPOSE: The **Select Parameters** module, in the **WHAT-IF SCENARIOS** pulldown menu, is used to specify the parameters for pre-treating and concentrating water in the **Vary Recovery**, **Vary pH**, and **3D Profile** modules.

WHEN SHOULD IT BE USED? Use the **Select Parameters** module to specify the minimum and maximum recovery rates and the increment between evaluation points in the **Vary Recovery** module. Use **Select Parameters** to specify whether or not pH control should be used. If pH control is selected as an option, the pH control point is entered in this module. The water where the control pH is measured is also specified. Chemists might prefer to specify pH control to the target pH in the concentrate, while an operator might specify pH control as measured in the feed water. The method for estimating pH (default or user defined pH-Alkalinity relationship) is also specified in the **Select Parameters** module. The Typical Temperature entered in this module is used for the calculations in the **Vary Recovery** and **Vary pH** modules.

The Operating Range Specifications entered in this module are used by the 3D PROFILE module which calculates indices at the Typical Recovery Rate entered, and over the Low to High pH ranges entered in this module.

PREREQUISITES: The **Input pH Curve** module should be run to input a user defined pH-Alkalinity relationship if you wish to use a custom curve for pH prediction.

What-if Scenario Specifications

pH Range Selection

Low pH High pH Increment %

Recovery Range Selection

Low % High % Increment %

pH Control Method

Acids

93% H2SO4

98% H2SO4

35% HCl

CO2

NONE

Alkalies

Caustic soda (NaOH)

Caustic potash (KOH)

Soda ash (Na2CO3)

Sodium bicarbonate (NaHCO3)

Lime (Ca(OH)2)

NONE

Control pH of

Feedwater

Brine

pH Target

pH Prediction Method

Default Curve User Curve Translate Source pH Caplan Curve

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery Vary pH Graph vs pH 3D Profile Select Parameters	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane		EDIT CORRELATION Edit Coefficients Browse Correlations				

SELECTION PURPOSE: The *Print Raw Water* module, in the **REPORTS** pull down menu, outputs the tables generated in the *Raw Water Analysis* module, the system diagram from **SYSTEM PARAMETERS Specifications** module spec sheet to the currently selected printer.

WHEN SHOULD IT BE USED? Use the *Print Raw Water* module whenever a hard copy of the water source and calculated indicators of scale potential and corrosivity is desired.

WHAT DOES IT DO? The module adds the date, sample ID, and analysis description information to the tables generated in the *Raw Water Analysis* module and prints them.

PREREQUISITES: The *Raw Water Analysis* module must be run prior to the *Print Raw Water* module. A printer should be active (see *Printer Setup* under the **FILES** pull down menu).

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery	Print Raw Water Print System Specs Print Summary	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane	Vary pH Graph vs pH 3D Profile Select Parameters	Print Recovery Profile Print pH Profile Print All		EDIT CORRELATION Edit Coefficients Browse Correlations		

SELECTION PURPOSE: The *Print System Specs* module, in the **REPORTS** pull down menu, outputs the system diagram from **SYSTEM PARAMETERS Specifications** module spec sheet to the currently selected printer.

WHEN SHOULD IT BE USED? Use the *Print System Specs* module whenever a hard copy of the specifications used for calculations is desired.

WHAT DOES IT DO? The module adds the date, sample ID, and analysis description information to the system diagram and table generated in the *Specifications* module and prints them.

PREREQUISITES: The *Specifications* module must be run prior to the *Print System Specs* module. Default values will be used if no other values have been entered. A printer should be active (see *Printer Setup* under the **FILES** pull down menu).

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery	Print Raw Water Print System Specs Print Summary	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane	Vary pH Graph vs pH 3D Profile Select Parameters	Print Recovery Profile Print pH Profile Print All	EDIT CORRELATION Edit Coefficients Browse Correlations			

SELECTION PURPOSE: The **Print Summary** module, in the **REPORTS** pull down menu, outputs the tables generated in the **Concentrate**.

WHEN SHOULD IT BE USED? Use the **Print Summary** module whenever a hard copy of the projected water chemistry and indicators of scale and corrosivity is desired at the target recovery rate.

WHAT DOES IT DO? The module adds the date, sample ID, and analysis description information to the tables generated in the **Concentrate** module and prints them.

PREREQUISITES: The **Concentrate** module must be run prior to the **Print Summary** module. A printer should be active (see **Printer Setup** under the **FILES** pull down menu).

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery	Print Raw Water Print System Specs Print Summary	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane	Vary pH Graph vs pH 3D Profile Select Parameters	Print Recovery Profile Print pH Profile Print All		EDIT CORRELATION Edit Coefficients Browse Correlations		

SELECTION PURPOSE: The **Print Recovery Profile** module, in the **REPORTS** pull down menu, outputs the tables generated in the module **Vary Recovery** .,

WHEN SHOULD IT BE USED? Use the **Print Recovery** module whenever a hard copy of the projected water chemistry and indicators of scale and corrosivity versus recovery is desired.

WHAT DOES IT DO? The module adds the date, sample ID, and analysis description information to the tables generated in the **Vary Recovery** module and prints them.

PREREQUISITES: The **Vary Recovery** module must be run prior to the **Print Recovery Profile** module. A printer should be active (see **Printer Setup** under the **FILES** pull down menu).

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery	Print Raw Water Print System Specs Print Summary Print Recovery Profile	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane	Vary pH Graph vs pH 3D Profile Select Parameters	Print pH Profile Print All		EDIT CORRELATION Edit Coefficients Browse Correlations		

SELECTION PURPOSE: The **Print pH Profile** module, in the **REPORTS** pull down menu, outputs the tables generated in the module **Vary pH**.

WHEN SHOULD IT BE USED? Use the **Print pH Profile** module whenever a hard copy of the projected water chemistry and indicators of scale and corrosivity versus pH is desired at the target recovery rate entered in the **Specifications** module..

WHAT DOES IT DO? The module adds the date, sample ID, and analysis description information to the tables generated in the **Vary pH** module and prints them.

PREREQUISITES: The **Vary pH** module must be run prior to the **Print pH Profile** module. A printer should be active (see **Printer Setup** under the **FILES** pull down menu).

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery Vary pH Graph vs pH 3D Profile Select Parameters	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data EDIT CORRELATION Edit Coefficients Browse Correlations	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane						

SELECTION PURPOSE: The **Print All** module, in the **REPORTS** pull down menu, outputs all of the tables available.

WHEN SHOULD IT BE USED? Use the **Print All** module whenever a hard copy of the all work completed is desired.

WHAT DOES IT DO? The module adds the date, sample ID, and analysis description information to the tables generated in module and prints them.

PREREQUISITES: The **Print All** module only runs available reports. For example, the **Vary pH** module must have been run for the pH Profile tables to be printed by **Print All**. A printer should be active (see **Printer Setup** under the **FILES** pull down menu).

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery Vary pH Graph vs pH 3D Profile Select Parameters	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane				EDIT CORRELATION Edit Coefficients Browse Correlations		

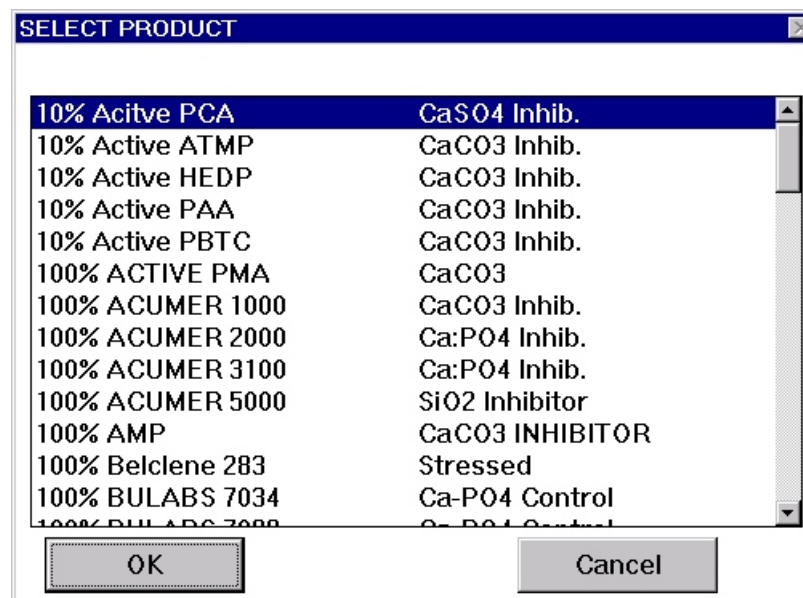
SELECTION PURPOSE: The **Select Product** module, in the **ANTISCALANT** pull down menu, lists the products on file and a description of their purpose, and allows you to select or change the product for which dosages will be calculated by the **WHAT-IF SCENARIO** modules.

WHEN SHOULD IT BE USED? Use the **Select Product** module to select a product for calculations or switch between products for calculations.

WHAT DOES IT DO? The module loads a product file including the mathematical correlations for the product which are used to calculate dosages from indices and operating parameters.

PREREQUISITES: A product file (*.PRD) must be in the \HYDRO\INHIB\ sub directory before it can be selected.

Product files are created in the **Input Product** module of the **ANTISCALANTS** pull down menu in the Formulator or Laboratory Editions.



hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery Vary pH Graph vs pH 3D Profile Select Parameters	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane			Input Product			

SELECTION PURPOSE: The **Input Product** module, in the **ANTISCALANTS** pull down menu is used to create a product (.PRD) file.

WHEN SHOULD IT BE USED? Use the **Input Product** module to create a new product file or modify an existing product file's Product Name, Description, or Formulation. NOTE: Inhibitors should be re-loaded into a formulation sheet when an inhibitor file is updated. Product files load a copy of the inhibitor file when they are created. They DO NOT automatically re-load a new file when the inhibitor data is updated.

WHAT DOES IT DO? The module accepts input data for a product file, loads the mathematical correlations for the individual inhibitors in the formulation, and outputs the new or updated product file.

PREREQUISITES: An inhibitor file (*.INH) must be in the \HYDRO\INHIB\ sub directory for each inhibitor which is an active ingredient.

Inhibitor files are created in the **Input Lab Data** module of the **LABORATORY** pull down menu in the Laboratory Editions. They can be created from in-house laboratory and/or field data, or obtained from raw material suppliers who use the French Creek Software Rx series programs as a technical support tool.

NOTES: 1) The product file name MUST end with the PRD extension, e.g. EXAMPLE.PRD

2) Enter % on an active, solids basis. e.g. If you are adding 10% of a 50% active PAA, enter 5%.

3) Push the button next to each ingredient for a list of Raw Materials (.INH) on file.

Inhibitor Formulation Input Form			
Formulation Name	<input type="text" value="10% Active HEDP"/>	Description	<input type="text" value="CaCO3 Inhib."/>
Product File Name	<input type="text" value="hedp10.prd"/>		
Inhibitor 1	<input type="text" value="HEDP"/>		<input type="text" value="10.000"/> %
Inhibitor 2	<input type="text"/>		<input type="text" value="0.000"/> %
Inhibitor 3	<input type="text"/>		<input type="text" value="0.000"/> %
Inhibitor 4	<input type="text"/>		<input type="text" value="0.000"/> %
Inhibitor 5	<input type="text"/>		<input type="text" value="0.000"/> %
Inhibitor 6	<input type="text"/>		<input type="text" value="0.000"/> %
Inhibitor 7	<input type="text"/>		<input type="text" value="0.000"/> %
Minimum Dosage	<input type="text" value="0.000"/> (mol/L)	% Actives	<input type="text" value="10.000"/> %
Password	<input type="text"/>	% Water	<input type="text" value="90.000"/> %
<input type="button" value="OK"/> <input type="button" value="Calc %"/> <input type="button" value="Delete File"/> <input type="button" value="Help"/> <input type="button" value="Cancel"/>			

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery Vary pH Graph vs pH 3D Profile Select Parameters	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane				EDIT CORRELATION Edit Coefficients Browse Correlations		

SELECTION PURPOSE: The *Input Lab Data* module, in the **LABORATORY** pull down menu is used to create inhibitor (.INH) files.

WHEN SHOULD IT BE USED? Use the Input Laboratory Data module to create a new inhibitor file from laboratory and/or field dosage and chemistry data, to modify an existing inhibitor file's Inhibitor Name, Description, to add or delete water chemistry data to modify the correlation..

WHAT DOES IT DO? The module accepts input data for a inhibitor file, calculates indices for each analysis-dosage entered, and uses multiple regression techniques to develop mathematical correlations for the inhibitor, and outputs the new or updated inhibitor (.INH) file.

PREREQUISITES: Five data points should be entered at a bare-bones minimum.

HINTS: 1) Enter dosages on an active, solids basis.
2) Simple tends to be better.

New Inhibitor Data Input

Inhibitor Name	<input type="text" value="PAA"/>	Raw Data File	<input type="text" value="PAA.COR"/>	
Inhibitor Purpose	<input type="text" value="CaCO3"/>	Output File	<input type="text" value="PAA.INH"/>	
Property Modeled	<input type="text" value="Scale Inhibitor Dosage"/>	<input type="text" value="Calcite [CaCO3]"/>		
Molecular Weight	<input type="text" value="2500.000000"/>	% Orthophosphate as PO4	<input type="text" value="0.000000"/>	ID# <input type="text" value="0"/>

Property	Variable	Transform	Lower Limit	Upper Limit
	<input type="text" value="Dosage"/>	<input type="text" value="LOG(X)"/>		
Variable 1	<input type="text" value="Calcite [CaCO3]"/>	<input type="text" value="LOG(X)"/>	<input type="text" value="-99.00"/>	<input type="text" value="-99.00"/>
Variable 2	<input type="text" value="Temperature"/>	<input type="text" value="1/RT"/>	<input type="text" value="-99.00"/>	<input type="text" value="-99.00"/>
Variable 3	<input type="text" value="Time"/>	<input type="text" value="LOG(X)"/>	<input type="text" value="-99.00"/>	<input type="text" value="-99.00"/>
Variable 4	<input type="text"/>	<input type="text"/>	<input type="text" value="-99.00"/>	<input type="text" value="-99.00"/>
Variable 5	<input type="text"/>	<input type="text"/>	<input type="text" value="-99.00"/>	<input type="text" value="-99.00"/>
Variable 6	<input type="text"/>	<input type="text"/>	<input type="text" value="-99.00"/>	<input type="text" value="-99.00"/>

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane	Vary pH Graph vs pH 3D Profile Select Parameters			EDIT CORRELATION Edit Coefficients Change Correlations		

SELECTION PURPOSE: The **Edit Coefficients** module, in the **LABORATORY** pull down menu is used to add safety factors, iron factors, and other customizing values to inhibitor (.INH) files.

WHEN SHOULD IT BE USED? Use the **Edit Coefficients** module when you wish to add a 10,20,30% or other safety factor to dosages predicted by the inhibitor model. Use the module to define a rule for dealing with iron, e.g. add 1 ppm of inhibitor for every ppm of iron above 1.8 .

WHAT DOES IT DO? The module accepts values that are used in the inhibitor models to increase dosages. The .INH file is updated to include the rules entered.

PREREQUISITES: An inhibitor file must exist.

FACTORS FOR SPECIAL CASES □ □ ×

INHIBITOR	<input type="text" value="AMP"/>	FILENAME	<input type="text" value="amp.inh"/>
PURPOSE	<input type="text" value="CaCO3 Scale Inhib."/>		
SAFETY FACTOR	<input type="text" value="0.000000"/>	1.1 increases by 10%, 1.2 by 20%, etc.	
IRON FACTOR			
Increase inhibitor dosage by	<input type="text" value="0.000000"/>	ppm for every ppm Fe above	<input type="text" value="0.000000"/>
PHOSPHATE FACTORS			
% Orthophosphate as PO4	<input type="text" value="0.000000"/>	% Organic phosphate as PO4	<input type="text" value="0.000000"/>
<input type="button" value="OK"/>		<input type="button" value="Cancel"/>	

hyd-RO-dose™ Menu Quick Reference

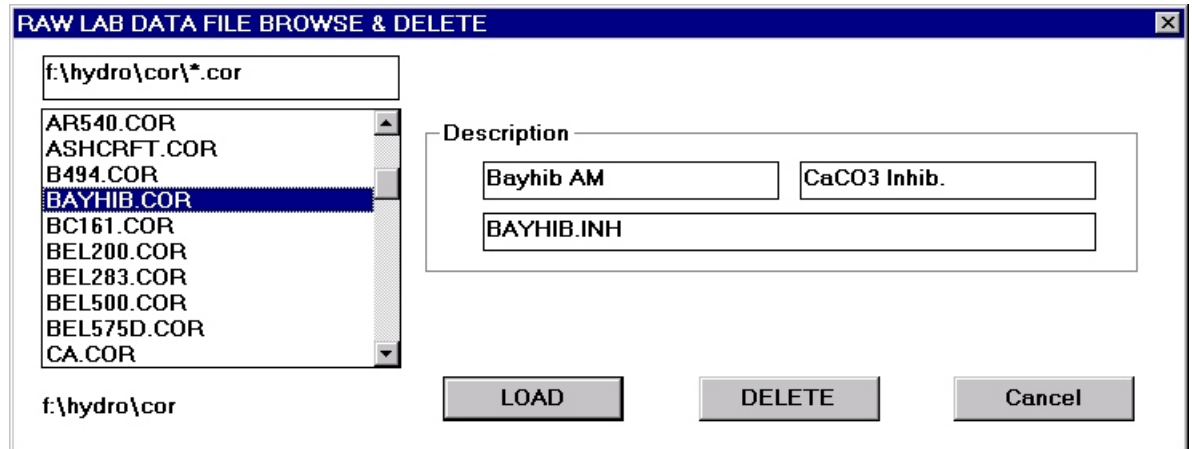
FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery Vary pH Graph vs pH 3D Profile Select Parameters	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane				EDIT CORRELATION Edit Coefficients Browse Correlations		

SELECTION PURPOSE: The **Browse Correlations** module, in the **LABORATORY** pull down menu to see what inhibitor names and descriptions are available.

WHEN SHOULD IT BE USED? Use the **Browse Correlation** module to see what inhibitors are available with raw laboratory data.

WHAT DOES IT DO? The module lists the inhibitors for which you have raw data.

PREREQUISITES: Correlation files must exist.



hyd-RO-dose™ Menu Quick Reference

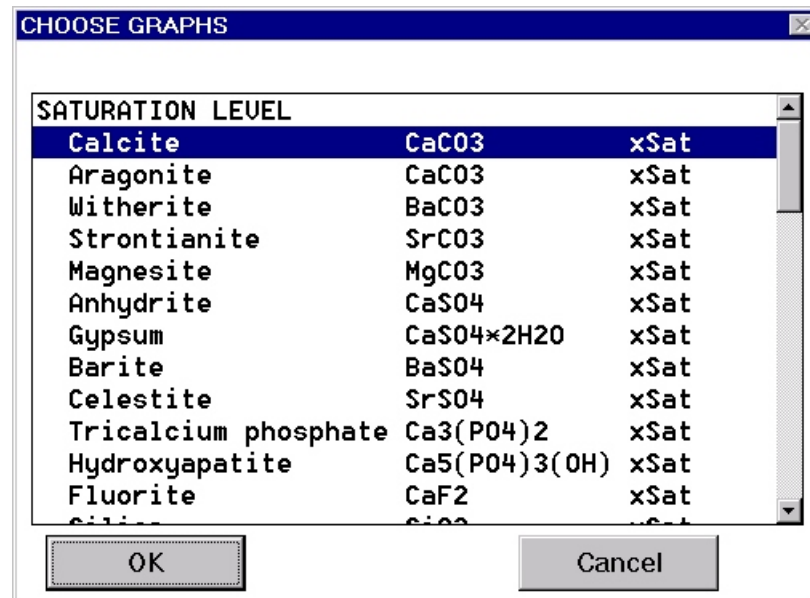
FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane	Vary pH Graph vs pH 3D Profile Select Parameters			EDIT CORRELATION Edit Coefficients Browse Correlations	Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	

SELECTION PURPOSE: Use the **Choose Graphs** module, in the **PREFERENCES** pull down menu, to select the indicators of scale and corrosivity potential for graphing in the **WHAT-IF SCENARIOS** modules.

WHEN SHOULD IT BE USED? Select **Choose Graphs** prior to running any of the graph presentation modules. You can also access **Choose Graphs** from the menu at the top of displayed graphs.

WHAT DOES IT DO? The **Choose Graphs** module allows you to select individual graphs or re-defined groups of four (4) graphs for presentation by the appropriate modules in the **WHAT-IF SCENARIO** group. The graphs are selected by the vertical scrolling menu shown at the right.

PREREQUISITES: None. The **Choose Graphs** menu can be run at any time from the main menu or when appropriate using the ALT and G hot key combo.



hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery Vary pH Graph vs pH 3D Profile Select Parameters	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane					EDIT CORRELATION Edit Coefficients Browse Correlations	

SELECTION PURPOSE: The **Input Units** module, in the **PREFERENCES** pull down menu, allows you to select the units of measure for the water analyses input. Water chemistry units are mg/l by default. The units ppm (parts per million) as the ion, or ppm as CaCO3 or epm (equivalents per million) as the ion can be selected in this module for input units. Alkalinity units can be specified as "M" and "P" alkalinity (as CaCO3), corrected or uncorrected HCO3 and CO3 in mg/l as the ions, or as milliliters of N/30 sulfuric acid. "M" and "P" alkalinity input are the default.

For example, you can select from Ca as Ca, or Ca as CaCO3 on this form. Other notable types are Fe as Fe, Fe as CaCO3, or Fe as Fe2O3. When this form is displayed, Buttons can be used to select preset analytical units as reported by major water treatment companies.

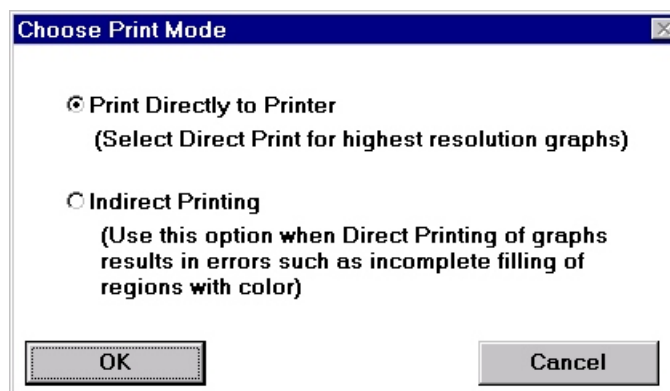
WHAT DOES IT DO? The **Input Units** module accepts the desired units for analyses entry via a user friendly entry form. French creek Software programs perform conversions of input data to its internal format based upon the input units selected in this module. Input unit preferences are stored in workspace save files (*.HYD).

PREREQUISITES: None.

NOTE: The Input Units module can also be accessed by pressing the CHANGE UNITS button on the **Raw Water Chemistry** input form.

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery Vary pH Graph vs pH 3D Profile Select Parameters	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode 3D Graph Types CO3 Calc's Constant Values Output Size On Screen	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane					EDIT CORRELATION Edit Coefficients Browse Correlations	

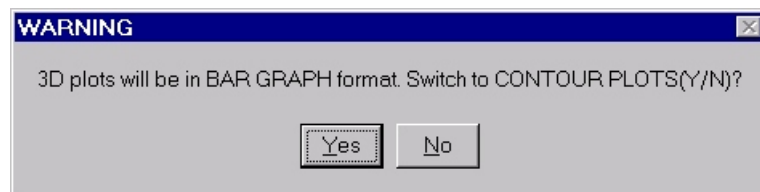


SELECTION PURPOSE: The **Print Mode** module, in the **PREFERENCES** pull down menu allows you to overcome the deficiency of some printer drivers. The default state is direct print. Use direct print unless problems with graph printouts are noted.

PREREQUISITES: None.

hyd-RO-dose™ Menu Quick Reference

FILES	INPUT	WHAT-IF SCENARIOS	REPORTS	ANTISCALANTS	LABORATORY	PREFERENCES	HELP
New Open File Save File Save File As Printer Setup What's Stored About hyd-RO-dose Quit	CHEMISTRY Raw Water Analysis Input pH Curve	Concentrate Vary Recovery Graph vs Recovery	Print Raw Water Print System Specs Print Summary Print Recovery Profile Print pH Profile Print All	Select Product Input Product	ANALYSIS INPUT Input Lab Data	Choose Graphs Input Units Print Mode	Technical Manual
	SYSTEM PARAMETERS Specifications Membrane	Vary pH Graph vs pH 3D Profile Select Parameters			EDIT CORRELATION Edit Coefficients Browse Correlations	3D Graph Types CO3 Calc's Constant Values Output Size On Screen	

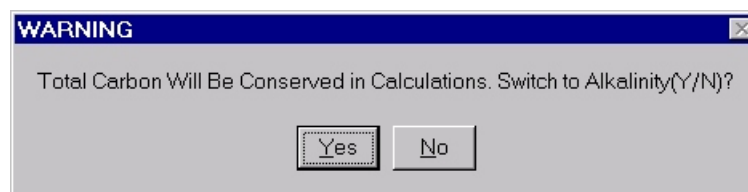


SELECTION PURPOSE: The **3D Graph Type** module, in the **PREFERENCES** pull down menu sets the initial graph type for 3D graphs as either the Bar or Contour type.

PREREQUISITES: None.

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	SYSTEM PARAMETERS Specifications Membrane	Vary pH Graph vs pH 3D Profile Select Parameters			EDIT CORRELATION Edit Coefficients Browse Correlations	CO3 Calc's Constant Values Output Size On Screen	



SELECTION PURPOSE: The **CO3 Calc's** module, in the **PREFERENCES** pull down menu allows the user to determine how the program will handle calculations involving carbon dioxide equilibrium with the atmosphere. The user can elect to conserve molar carbon in calculations or conserve alkalinity.

WHEN SHOULD IT BE USED? The **CO3 Calc's** module should rarely be used. The default method is to conserve molar carbon (Ct). This would be the case in a closed system which does not exchange CO₂ with the atmosphere. The other option is to conserve alkalinity in calculations. This would be expected for an open system which freely exchanges CO₂ with the atmosphere. In many cases, only minor differences in calculated values will be observed between methods.

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	SYSTEM PARAMETERS Specifications Membrane						

Select Constant Recirculating Water Concentrations

Constant Phosphate 0. (as PO₄)

Constant Silica 0. (as SiO₂)

OK Help Cancel

SELECTION PURPOSE: The **Constant Values** module, in the **PREFERENCES** pull down menu allows the user to set a constant water phosphate and/or silica level. This module allows the user to over-ride the calculated value which would normally be used.

WHEN SHOULD IT BE USED? The Constant Values module should be used to model a water where the phosphate and/or silica levels are maintained at a constant level through periodic testing and chemical feed pump adjustment.

WHAT IT DOES: This module forces the water chemistry calculations to be made using the a constant water phosphate concentration, and/or constant water silica level.

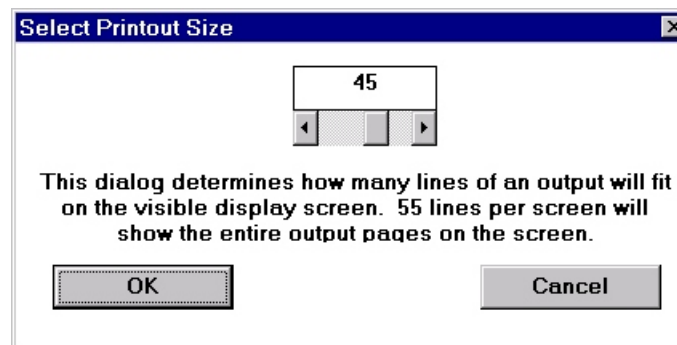
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	SYSTEM PARAMETERS Specifications Membrane	Vary pH Graph vs pH 3D Profile Select Parameters			EDIT CORRELATION Edit Coefficients Browse Correlations	Output Size On Screen	

SELECTION PURPOSE: The **Output Size On Screen** module, in the **PREFERENCES** pull down menu, allows you to change the size of the output windows which display water chemistry and calculated values.

HINTS: 55 lines allows all windows to be displayed.

CAUTION: This option only works if the appropriate fonts are installed on your computer. You may see the size of windows change from small to very large with few increments.



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SELECTION PURPOSE: The **Technical Manual** module, in the **HELP** pull down menu, displays an on-line version of this User Manual.

The screenshot shows the 'hyd-RO-dose' application window. At the top is a menu bar with 'File', 'Edit', 'Bookmark', and 'Help'. Below the menu bar is a navigation toolbar with buttons for 'Contents', 'Search', 'Back', 'History', and 'Annotate Topic'. Below the toolbar is a list of topics under the heading 'WHY USE hyd-RO-dose?'. The topics are: 'WHAT INDICATORS DOES hyd-RO-dose CALCULATE?' (with sub-topics: The Langelier Saturation Index, RYZNAR STABILITY INDEX, Stiff-Davis Saturation Index, PUCKORIUS SCALING INDEX, MOMENTARY EXCESS (PRECIPITATION TO EQUILIBRIUM), LARSON-SKOLD INDEX, SATURATION LEVEL), 'INTERPRETING hyd-RO-dose INDICES' (with sub-topics: hyd-RO-dose COLOR CODING), 'WHAT-IF SCENARIO MODELING' (with sub-topics: pH PREDICTION, hyd-RO-dose Rx Series, hyd-RO-dose Rx Files), 'DOSAGE MODULATION', 'INPUTTING A PRODUCT FORMULATION', 'DEVELOPING INHIBITOR MODELS', and 'REFERENCES'.