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CITY OF SACRAMENTO

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CITY OF SACRAMENTO
City Clerk
Historic City Hall, First Floor
915 I Street
Sacramento, CA 95814

LAKE MAINTENANCE AGREEMENT

This LAKE MAINTENANCE AGREEMENT ("Agreement") is made and entered into in Sacramento, California, on April 17, 2006, by and between Natomas Investors, LLC, a Delaware limited liability company, George Tsakopoulos and Drosoula Tsakopoulos as Trustees of the Tsakopoulos Family Trust dated August 5, 1991, and K. Hovnanian Forecast Homes, Inc., a California corporation (collectively referred to as "Owner") and the CITY OF SACRAMENTO, a charter city ("City").

CITY AGREEMENT NO. 2006-0383

**RECITALS**

**A.** The Owner owns all legal and equitable interests in the real property (the "Property") in the City of Sacramento described in Exhibit "A" and depicted in Exhibit "B," each of which exhibits is attached hereto and incorporated herein by this reference.

**B.** The City has approved a tentative master parcel map (the "tentative map") for development of the Property for residential purposes, known as "Natomas Central," City Planning No. P04-173 (the "Project").

**C.** As a condition of approval of the tentative map, and pursuant to the approved drainage plan for the Property and a separate drainage agreement, the Owner will be required to construct a lake (the "Lake") and related common drainage facilities on the portion of the Property identified as Parcel 44 on the tentative map ("Parcel 44").

**D.** Owner also is required to form a Home Owners' Association ("HOA") to be responsible for maintaining the Lake, as provided in the following condition of approval of the tentative map (that identifies Owner as the "applicant"):

I38 The Homeowners Association (HOA) shall be responsible for maintaining the water quality, landscaping and aesthetics of the lake. The Department of Utilities shall be responsible for maintaining the outfall structures, weir structure, and pump station and discharge pipes. The lake water surface


CITY AGREEMENT NO. 2006-0383

shall be maintained at an elevation determined solely by the Department of Utilities. Cleanup after a storm event is the responsibility of the HOA and property owners. The applicant shall execute an agreement with the City, which delineates the maintenance responsibilities of the HOA. This agreement shall include a provision, which, in the event of the HOA's failure to adequately perform their maintenance responsibilities, allows the Department of Utilities to perform maintenance and be reimbursed for such maintenance by the HOA. The agreement shall be to the satisfaction of the Department of Utilities and the City Attorney.

E. The Owner also is required as a condition of approval of the tentative map to dedicate Parcel 44 to the City, reserving an easement for the HOA to access and maintain the lake in accordance with the Owner's approved lake management plan. A copy of the approved lake management plan is attached hereto as Exhibit "C."

F. The Owner and City are entering into this Agreement to satisfy the provisions of Condition I38 set forth above.

**NOW THEREFORE**, the City and Owner mutually agree as follows:

1. The foregoing recitals are incorporated herein by this reference.

2. Owner shall, prior to and as a condition of City's acceptance of the Lake and common drainage facilities described in Condition I26 of the tentative map:

   a. Form a duly constituted and legally sufficient HOA; and

   b. Provide City with an assumption and assignment agreement, in such form as may be required by the City Attorney, whereby the HOA unconditionally assumes and becomes wholly responsible for the performance of each and every obligation imposed on Owner hereunder.

   Notwithstanding any contrary provision of this Agreement, upon City's acceptance of and written consent to such assumption and assignment agreement, Owner shall be released from any obligations arising under this Agreement relating to any Lake maintenance activities required to be performed after the date of such consent.

3. Upon construction and City acceptance of the Lake, Owner shall be responsible for maintaining the water quality, landscaping and aesthetics of the Lake. Owner shall at its sole expense use its best efforts to diligently maintain the water quality, landscaping and aesthetics of the Lake so that the Lake level at all times is maintained at the elevation(s) required by the City's Department of Utilities, and the Lake and adjacent landscaping at all times has a clean and orderly appearance in accordance with the provisions of the Owner's approved lake management plan and this Agreement. Compliance with the foregoing obligations shall include, but is not limited to, performance of the maintenance measures specified on Exhibit "D," attached hereto and incorporated herein by

this reference. The City shall be authorized to periodically modify the approved lake management plan for purposes of flood control and/or water quality protection.

4. If Owner fails to perform the measures required by this Agreement, within ten (10) days of being given written notice to do so by the City in the case of a condition involving a threat to the public health or safety, or within thirty (30) days of being given written notice to do so by City in all other instances, the City is hereby authorized, but shall not be required, to cause any such measures to be performed and charge the entire cost and expense to the Owner, including reasonable administrative and legal costs and interest thereon at the maximum rate authorized by the Civil Code from the due date of the City's invoice until paid in full. Owner shall pay such City invoice not later than thirty (30) days after receipt.

5. Owner agrees that this Agreement establishes and imposes on the Property (excluding any parcels dedicated to the City) a lien in such amount as will fully reimburse the City for any and all costs incurred pursuant to section 3, above, including interest as set forth above, subject to foreclosure in any event of the Owner's default in payment as required herein. This remedy is in addition to any other remedy available to City at law or in equity for the Owner's default in payment or other breach of this Agreement.

6. This Agreement shall be recorded in the Office of the Recorder of Sacramento County, California, and shall constitute notice to all successors of title to the Property of the obligations herein set forth.

7. By providing for proper maintenance of the Lake this Agreement benefits the Property, and it is the intent of the parties that burdens and benefits herein undertaken shall constitute covenants that run with the Property in accordance with Section 1468 of the Civil Code.

8. The obligations herein undertaken shall be binding upon the heirs, successors, executors, administrators and assigns of the parties; provided that this agreement may only be assigned by Owner with the written consent of City as provided above, and any purported assignment without such consent shall be void.

9. Owner certifies that it owns full legal title to the Property. Each individual executing this Agreement on behalf of a corporation or partnership represents and warrants to City that he or she has been authorized to do so by the entity on whose behalf he or she executes this Agreement and that said entity will thereby be obligated to perform the terms of this Agreement.

10. If Owner consists of more than one party, each such party shall be jointly and severally liable for each and every obligation and requirement imposed on Owner herein.



CITY 2006-0383
AGREEMENT NO._____

11. If the services of any attorney are required by either party to secure the performance of this Agreement, or otherwise upon the breach or the default of either party, or if any judicial remedy or arbitration is necessary to enforce or interpret any provision of this Agreement, the prevailing party shall be entitled to reasonable attorney fees, costs, and other expenses, in addition to any other relief to which such party may be entitled.

12. Owner, for itself and all successors, releases any and all claims of whatever sort or nature that may arise against the City, its officers, employees, agents, contractors and subcontractors, in connection with any injury or damage to persons or property arising from the Owner's performance or failure to perform the maintenance measures specified herein; this waiver shall include any and all claims arising under Section 1542 of the California Civil Code, which provides that:

> "A general release does not extend to claims which the creditor does not know or suspect to exist in his favor at the time of executing the release, which if known by him must have materially affected his settlement with the debtor."

Thus, notwithstanding the provisions of Section 1542, and for the purpose of implementing a full and complete release, Owner expressly acknowledges that this Agreement is intended to release and extinguish, without limitation, all claims for loss of any sort or nature arising hereunder that Owner does not know or suspect to exist.

13. Owner shall defend, indemnify and hold harmless City, its officers, employees and agents against and from all actions, damages, costs, liability, claims, losses, judgments, penalties and expenses of every type and description, including, but not limited to, any fees and/or costs reasonably incurred by City's staff attorneys or outside attorneys and any fees and expenses incurred in enforcing this provision, arising directly or indirectly from any action or failure to act by Owner, its officers, employees, contractors or agents in connection with this Agreement.

14. Time is of the essence in the performance of this Agreement.

15. Any notice to a party required or called for in this Agreement shall be served in person, or by deposit in the U.S. Mail, first class postage prepaid or by overnight courier service, to the address set forth below. Notice(s) shall be deemed effective and received upon receipt, or seventy-two (72) hours after deposit in the U.S. Mail or upon the next business day if sent by overnight courier, whichever is earlier. A party may change a notice address only by providing written notice thereof to the other party. Notices to Owner shall be directed as follows:

K. Hovnanian Forecast Homes, Inc.
1375 Exposition Boulevard, Suite 300

CITY AGREEMENT NO. 2006-0383

Sacramento, California 95815
Attn: Richard J. Balestreri
Phone: (916) 920-0200
Facsimile: (916) 920-0379

With a copy to: Law Offices of Gregory D. Thatch
1730 "I" Street, Suite 220
Sacramento, California 95814
Attn: Michael Devereaux, Esq.
Phone: (916) 443-6956
Facsimile: (916) 443-4632

Natomas Investors, LLC
c/o Farallon Capital Management , LLC
One Maritime Plaza, Suite 1325
San Francisco, California 94111
Attn: Robert B. Fried
Phone: (415) 421-2151
Facsimile: (415) 421-2133

With a copy to: Pircher, Nichols & Meeks
1925 Century Park East, Suite 1700
Los Angeles, California 90067
Attn: Real Estate Notices (SAC/JAB)
Phone: (310) 201-8922
Facsimile: (310) 201-8900

Tsakopoulos Family Trust dated August 5, 19991
c/o Tsakopoulos Investments
7423 Fair Oaks Blvd., Suite 10
Carmichael, California 95608
Attn: George Tsakopoulos, Trustee
Phone: (916) 972-7000
Facsimile: 9916) 972-8708

IF TO CITY:

Director of Utilities
City of Sacramento, Department of
Utilities
1395 35th Avenue
Sacramento, CA 95822-2911

CITY AGREEMENT NO. 2006-0383

16. Any revision or amendment to this Agreement must be approved by both parties in writing.

17. This Agreement may be executed in multiple counterparts, each of which shall be deemed an original, but all of which, together, shall constitute one and the same instrument.

**IN WITNESS THEREOF**, the parties hereto have affixed their signatures as of the date first written above.

**CITY OF SACRAMENTO:**

Cassandra H.B. Jennings

By: Cassandra H.B. Jennings, Asst. City Mgr.
For: Ray Kerridge City Manager

**APPROVED AS TO FORM:**

City Attorney

**ATTEST:**

Dawn Bullwinkle
asst City Clerk 4/17/06

**OWNER:**
K. HOVNANIAN FORECAST HOMES, INC.
a California corporation

By: _____
Richard J. Balestreri
Senior Vice President

NATOMAS INVESTORS, LLC
a Delaware limited liability company
By: Farallon Capital Management, LLC
a Delaware limited liability company

By: _____
Stephen L. Millham
Managing Member

GEORGE TSAKOPOULOS and DROSOULA TSAKOPOULOS, TRUSTEES OF THE TSAKOPOULOS FAMILY TRUST DATED AUGUST 5, 1991

By: _____
George Tsakopoulos
Trustee

By: _____
Drosoula Tsakopoulos
Trustee

CITY
AGREEMENT NO. 2006-0383

**STATE OF CALIFORNIA** )
) **ss.**
**COUNTY OF** Sacramento )

On 04/14/06 before me, Lori B. Gay a Notary Public (here insert name and title of the officer), personally appeared Cassandra H. B. Jennings, personally known to me (or proved to me on the basis of satisfactory evidence) to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies), and that by his/her/their signature(s) on the instrument the person(s), or the entity upon behalf of which the person(s) acted, executed the instrument.

**WITNESS** my hand and official seal.

LORI B. GAY
Comm. # 1563200
NOTARY PUBLIC-CALIFORNIA
Sacramento County
My Comm. Expires March 22, 2009

Signature Lori B. Gay (Seal)

**STATE OF** _____ )
) **ss.**
**COUNTY OF** _____ )

On _____ before me, _____ a Notary Public (here insert name and title of the officer), personally appeared _____, personally known to me (or proved to me on the basis of satisfactory evidence) to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies), and that by his/her/their signature(s) on the instrument the person(s), or the entity upon behalf of which the person(s) acted, executed the instrument.

**WITNESS** my hand and official seal.

Signature _____ (Seal)



CITY AGREEMENT NO. 2006-0383

16. Any revision or amendment to this Agreement must be approved by both parties n writing.

17. This Agreement may be executed in multiple counterparts, each of which shall be deemed an original, but all of which, together, shall constitute one and the same instrument.

**IN WITNESS THEREOF**, the parties hereto have affixed their signatures as of the date first written above.

**CITY OF SACRAMENTO:**

_____
Gary Reents
Director, Department of Utilities

**APPROVED AS TO FORM:**

_____
City Attorney

**ATTEST:**

_____
City Clerk

**OWNER:**
K. HOVNANIAN FORECAST HOMES, INC.
a California corporation

By: _____
Richard J. Balestreri
Senior Vice President

NATOMAS INVESTORS, LLC
a Delaware limited liability company
By: Farallon Capital Management, LLC
a Delaware limited liability company

By: _____
Stephen L. Millham
Managing Member

GEORGE TSAKOPOULOS and DROSOULA TSAKOPOULOS, TRUSTEES OF THE TSAKOPOULOS FAMILY TRUST DATED AUGUST 5, 1991

By: _____
George Tsakopoulos
Trustee

By: _____
Drosoula Tsakopoulos
Trustee



CITY
AGREEMENT NO. 2006-0383

STATE OF CALIFORNIA )
) ss.
COUNTY OF _____ )

On _____ before me, _____ a Notary Public (here insert name and title of the officer), personally appeared _____, personally known to me (or proved to me on the basis of satisfactory evidence) to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies), and that by his/her/their signature(s) on the instrument the person(s), or the entity upon behalf of which the person(s) acted, executed the instrument.

**WITNESS** my hand and official seal.

Signature _____ (Seal)

STATE OF California )
) ss.
COUNTY OF San Francisco )

On 4/13/06 before me, Ann Tyson Golden a Notary Public (here insert name and title of the officer), personally appeared Stephen C. Millhouse personally known to me (or proved to me on the basis of satisfactory evidence) to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies), and that by his/her/their signature(s) on the instrument the person(s), or the entity upon behalf of which the person(s) acted, executed the instrument.

**WITNESS** my hand and official seal.

Signature _____ (Seal)

ANN TYSON GOLDEN
Commission # 1526376
Notary Public - California
San Francisco County
My Comm. Expires Nov 13, 2008



CITY
AGREEMENT NO. 2006-0383

16. Any revision or amendment to this Agreement must be approved by both parties n writing.

17. This Agreement may be executed in multiple counterparts, each of which shall be deemed an original, but all of which, together, shall constitute one and the same instrument.

**IN WITNESS THEREOF**, the parties hereto have affixed their signatures as of the date first written above.

**CITY OF SACRAMENTO:**

Gary Reents
Director, Department of Utilities

**APPROVED AS TO FORM:**

City Attorney

**ATTEST:**

City Clerk

**OWNER:**
K. HOVNANIAN FORECAST HOMES, INC.
a California corporation

By: _____
Richard J. Balestreri
Senior Vice President

NATOMAS INVESTORS, LLC
a Delaware limited liability company
By: Farallon Capital Management, LLC
a Delaware limited liability company

By: _____
Stephen L. Millham
Managing Member

GEORGE TSAKOPOULOS and DROSOULA TSAKOPOULOS, TRUSTEES OF THE TSAKOPOULOS FAMILY TRUST DATED AUGUST 5, 1991

By _____ TRUSTEE
George Tsakopoulos
Trustee

By: Drosoula Tsakopoulos, Trustee
Drosoula Tsakopoulos
Trustee



CITY AGREEMENT NO. 2006-0383

STATE OF CALIFORNIA )
COUNTY OF SACRAMENTO )

On 4/17/06 before me, Sandra L. Franzago
DATE
Personally appeared, Richard S. Balestreri

personally known to me (or proved to me on the basis of satisfactory evidence) to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies), and that by his/her/their signature(s) on the instrument the person(s), or the entity upon behalf of which the person(s) acted, executed the instrument.

WITNESS my hand and official seal.

SANDRA L. FRANZAGO
COMM. # 1631861
NOTARY PUBLIC-CALIFORNIA
SACRAMENTO COUNTY
MY COMM. EXP. JAN. 1, 2010

_____ (SEAL)
NOTARY PUBLIC SIGNATURE

CITY
AGREEMENT NO. 2006-0383

STATE OF CALIFORNIA )
) ss.
COUNTY OF SACRAMENTO )

On April 14, 2006 before me, BARBARA L. VICKERY a Notary Public (here insert name and title of the officer), personally appeared DROSOULA TSAKOPOULOS personally known to me ~~(or proved to me on the basis of satisfactory evidence)~~ to be the person~~(s)~~ whose name~~(s)~~ is~~/are~~ subscribed to the within instrument and acknowledged to me that ~~he~~/she/~~the~~y executed the same in ~~his~~/her/~~their~~ authorized capacity~~(ies)~~, and that by ~~his~~/her/~~their~~ signature~~(s)~~ on the instrument the person~~(s)~~, or the entity upon behalf of which the person~~(s)~~ acted, executed the instrument.

**WITNESS** my hand and official seal.

BARBARA L. VICKERY
Commission # 1472553
Notary Public - California
Sacramento County
My Comm. Expires Feb 24, 2008

Signature Barbara L Vickery (Seal)

STATE OF CALIFORNIA )
) ss.
COUNTY OF SACRAMENTO )

On April 14, 2006 before me, BARBARA L. VICKERY a Notary Public (here insert name and title of the officer), personally appeared GEORGE TSAKIROPOULOS, personally known to me (~~or proved to me on the basis of satisfactory evidence~~) to be the person~~(s)~~ whose name~~(s)~~ is~~/are~~ subscribed to the within instrument and acknowledged to me that he~~/she/the~~y executed the same in his~~/her/their~~ authorized capacity~~(ies)~~, and that by his~~/her/their~~ signature~~(s)~~ on the instrument the person~~(s)~~, or the entity upon behalf of which the person~~(s)~~ acted, executed the instrument.

**WITNESS** my hand and official seal.

BARBARA L. VICKERY
Commission # 1472553
Notary Public - California
Sacramento County
My Comm. Expires Feb 24, 2008

Signature Barbara L Vickery (Seal)



CITY
AGREEMENT NO. 2006-0383

EXHIBIT "A"

Lots 34, 35, 36, 37, 38, 39 and 40 as shown on the Map of Natomas Central Subdivision recorded in 16 B.M. 3 Sacramento County Records and Parcel 2 as shown on Lot Line Adjustment recorded 20041006 O.R. 2274, Sacramento County Records, in the City and County of Sacramento, State of California.



CITY AGREEMENT NO. 2006-0383

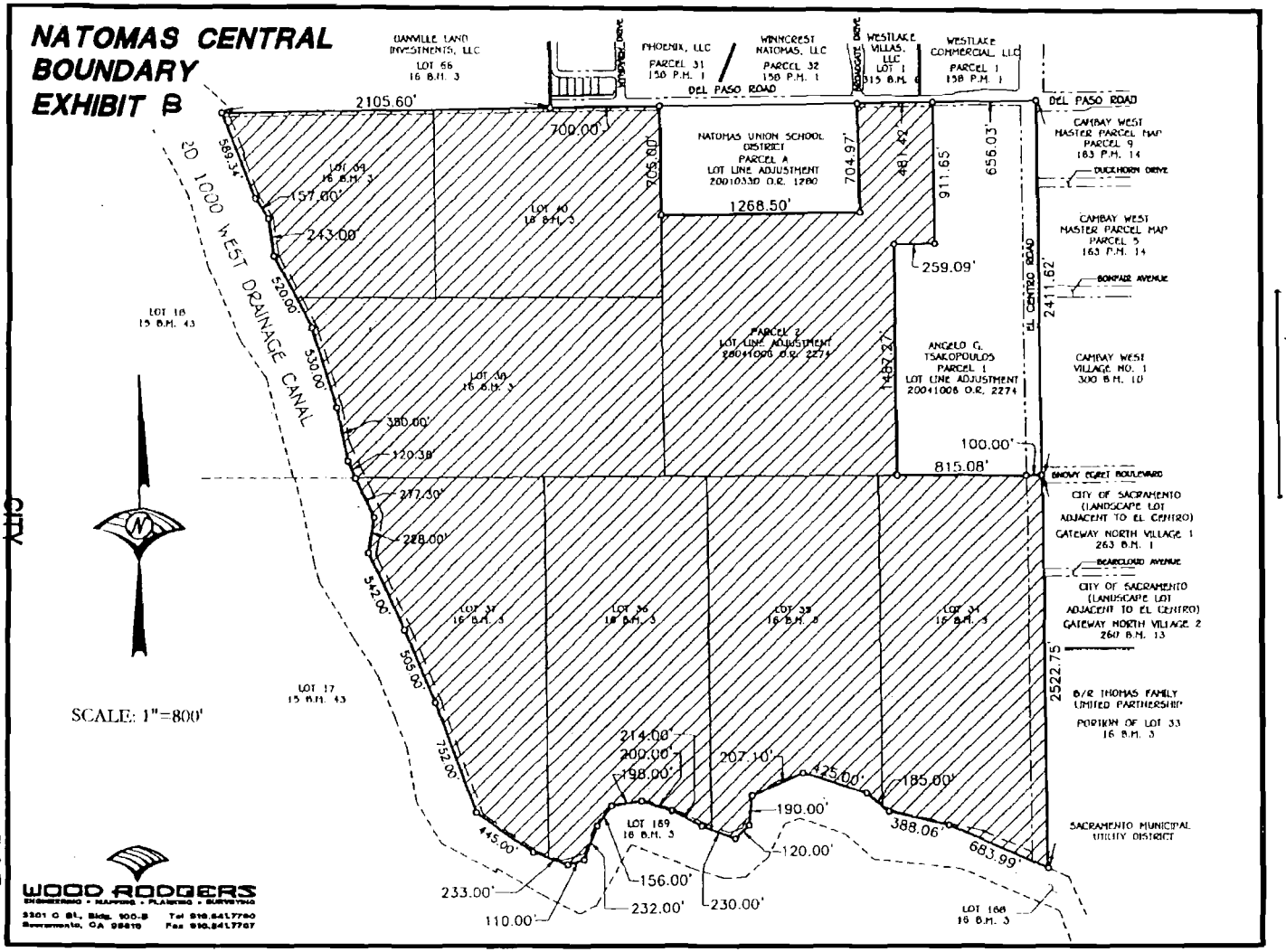


Exhibit B

CITY AGREEMENT NO. 2006-0383

Exhibit C



# NATOMAS CENTRAL LAKE MANAGEMENT PLAN

PERRY LAKE MANAGEMENT

APPLIED ECOLOGY

WOOD RODGERS, INC.

# NATOMAS CENTRAL
# LAKE MANAGEMENT PLAN

*Prepared For:*

K. Hovnanian Homes
1796 Tribute Road, Suite 100
Sacramento, CA 95815

*Prepared By:*

Stuart Perry
Perry Lake Management
P.O. Box 4122
Stockton, CA 95204

Mark D. Sytsma, Ph.D.
Applied Technology
P.O. Box 2421
Tualatin, OR 97062

and

Wood Rodgers, Inc.
3301 C Street, Bldg. 100-B
Sacramento, CA 95816

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# TABLES



# FIGURES

# SUMMARY

The centerpiece of the Natomas Central development is an approximately 28-acre lake that will provide aesthetic and limited recreational uses for residents. The lake will also serve as a drainage detention basin for flood control and water quality enhancement for the Natomas Central development and land to the north and east of the development within the same drainage basin. The lake will be part of a comprehensive set of best management practices developed to manage storm water runoff from the development. The lake will be operated as a vegetated wet pond. Rooted aquatic plants will sequester nutrient pollutants in runoff and enhance the function of the lake as a sedimentation basin. Water level during the summer will be maintained by input of groundwater via a well.

If high nutrient concentrations are present the well water, excessive algae growth may occur, particularly before aquatic vegetation is well established. Excessive algae growth may create nuisance conditions in the summer that require management to meet use and water quality objectives. Excessive algae can be managed using appropriate dose and formulation of algaecides following City approval. Aquatic plant harvesting will be conducted regularly to remove sequestered nutrients.

Monitoring will be an integral part of the management plan for the lake. Regular monitoring will document the efficacy of the management plan and allow for informed decisions about future management options. Monitoring will include quarterly measurement of lake level, water transparency, temperature and dissolved oxygen, pH, nutrients, chlorophyll, water column metals, and coliform bacteria. Metals in plants will be measured prior to each harvest. Metals in sediments will be measured once per year. Quarterly and annual reports on the monitoring results will be produced and submitted to the City.

A public education program is recommended to provide information to residents on best management practices, to prevent aquatic weed infestation and development of a resident waterfowl community, and to explain the management objectives and operation of the wet pond for storm water treatment.

# NATOMAS CENTRAL LAKE MANAGEMENT PLAN

This report provides a description of the expected condition and required management activities for the lake at the Natomas Central development. Management objectives for the lake and a management strategy for meeting those objectives are provided. The Plan will be implemented by a qualified lake management firm under contract with the homeowners association.

## INTRODUCTION

Lakes are valuable amenities that provide recreational, aesthetic, and wildlife habitat benefits to residential communities. Lakes contain their own biological communities, however, that change in response to seasons and physical and chemical characteristics of the water. The chemical and physical characteristics of the water are, in turn, determined by the soils, activities, and land use in the watershed of the lake. Runoff from residential watersheds can enter lakes through storm drains. Urban runoff contains numerous constituents that can influence the biological communities in lakes that receive the runoff.

Productivity, or the amount of biological activity in lakes, is determined by a combination of hydrologic, chemical, and biological factors. Often, lake productivity is determined by the amount of nutrients entering the lake. The importance of nutrient loading of lakes in determining lake status is reflected in the way lakes are typically classified by trophic state. Trophic state refers to the level of primary production (plant growth) in a lake. Lakes with abundant of algae and aquatic plants are termed eutrophic (well-fed), lakes with little plant growth are termed oligotrophic (poorly fed), lakes somewhere in between are termed mesotrophic (medium-fed). Urban runoff can contribute nutrients to lakes that stimulate productivity. The increase in lake productivity caused by human activity in the watershed is termed cultural eutrophication. Cultural eutrophication can lead to nuisance conditions, including excessive algae and aquatic plant growth.

Trophic state can be determined by examining several lake characteristics that are correlated with productivity (Table 1). Trophic state indices based transparency, total phosphorus concentration, and chlorophyll *a* concentration (Carlson 1977) are also commonly used to classify lake trophic state. According to Carlson's indices, a TSI less than 40 indicates an oligotrophic state, a TSI between 45 and 50 indicates mesotrophy, and a TSI greater than *53* indicates eutrophy.

**Table 1. Qualitative Characteristics of Oligotrophic and Eutrophic Lakes (Adapted from Welch 1980)**

| Characteristic | Trophic State | |
|---|---|---|
| | *Oligotrophic* | *Eutrophic* |
| Depth | Deep | Shallow |
| Hypolimnion:epilimnion | >1 | <1 |
| Primary production | Low | High |
| Rooted macrophytes | Few | Abundant |
| Phytoplankton density | Low | High |
| Number of phytoplankton species | Few | Many |
| Frequency of phytoplankton blooms | Rare | Common |
| Hypolimnion dissolved oxygen depletion | No | Yes |
| Nutrient supply | Low | High |
| Fish species | Cold water, slow growth, restricted to hypolimnion | Warm water, fast growth, tolerate low to oxygen in hypolimnion and high temperatures in epilimnion |

Cultural eutrophication is a major determinant of lake trophic state, but it is not the sole determinant. Other factors, such as hydrology and interactions among the biota in a lake, also play a role. Hydrology influences trophic state by a flushing action. If the rate that water moves through a lake is high enough, algae are washed out of the lake faster than they can reproduce, which leads to low algae densities and oligotrophic, clear-water conditions.

The structure of the food web in a lake can also influence the amount of algae present and the trophic state of a lake. Algae are eaten by zooplankton (tiny, nearly microscopic animals). An abundance of zooplankton can keep algae densities low and the water clear. Small fish eat zooplankton, however, and when small fish are abundant zooplankton densities are low, algae densities high, and the water turbid — a eutrophic condition. Another link in the food chain can be added — large fish that eat small fish — which results in few small fish, abundant zooplankton, few algae and clear water. Clear-water conditions can also occur in lakes with high nutrient loading if abundant macrophytes are present. Macrophytes compete with algae for light and nutrients in the water column, and there is evidence that shallow, high-nutrient lakes can exist in two states: a turbid, algae dominated state; and a clear-water, macrophyte dominated state. Altering the structure of the food web or changing the relative abundance of macrophytes and algae, a technique termed biomanipulation, can therefore cause changes in the water quality of a lake and has been used successfully to reduce algae densities and enhance water quality in eutrophic lakes.

## THE NATOMAS CENTRAL PROJECT

The Natomas Central Project is a 398-acre mixed-use development located in the North Natomas area of Sacramento, California. The Project will include 1,749 residential lots and 594 multi-family units, elementary school, three community parks, open space, and private recreational center are also planned. An existing middle school to the north and a proposed neighborhood commercial site to the northeast are also in the drainage shed, but not a part of the Natomas Central Project. Natomas Central will be located to the southwest of the intersection of El Centro and Del Paso Roads and to the northeast of the RD 1000 West Drain Canal (Figure 1). The topography of the area is essentially flat and is currently undeveloped agricultural land. A north/south trending irrigation canal bisects the central portion of the project area.

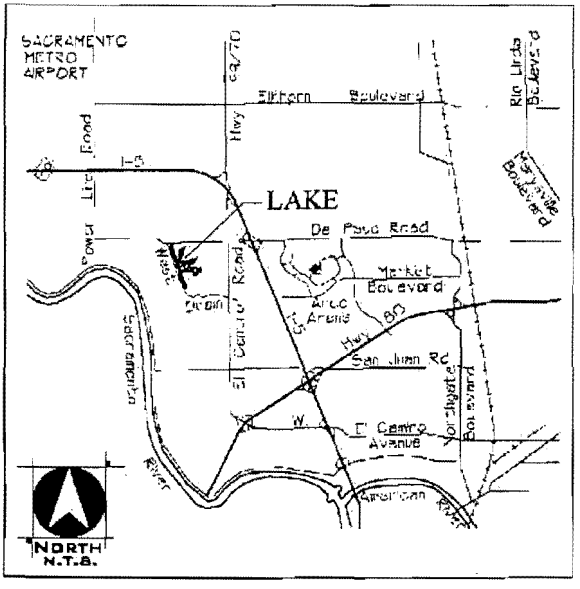


**Figure 1. Vicinity Map for Natomas Central Lake**

*Design*

The lake at Natomas Central is designed as an amenity for the residents and to provide flood control and water quality enhancement of surface water runoff from the development and surrounding areas (Figure 2). The lake is designed as a wet basin, and will contain water year-round. The approximately 28-acre lake basin will be surrounded by a perimeter headwall that is 24 inches above the expected winter water surface elevation and 12 inches above the expected summer water elevation. For public safety, typical grading will include a perimeter shelf approximately four feet wide and 0.7 to 1.7 feet deep, depending upon the season. The lakebed will slope from the perimeter shelf to a maximum depth of 9.5 feet at a 3:1 or flatter slope. The lake bottom will include a 12-inch-thick native clay layer.

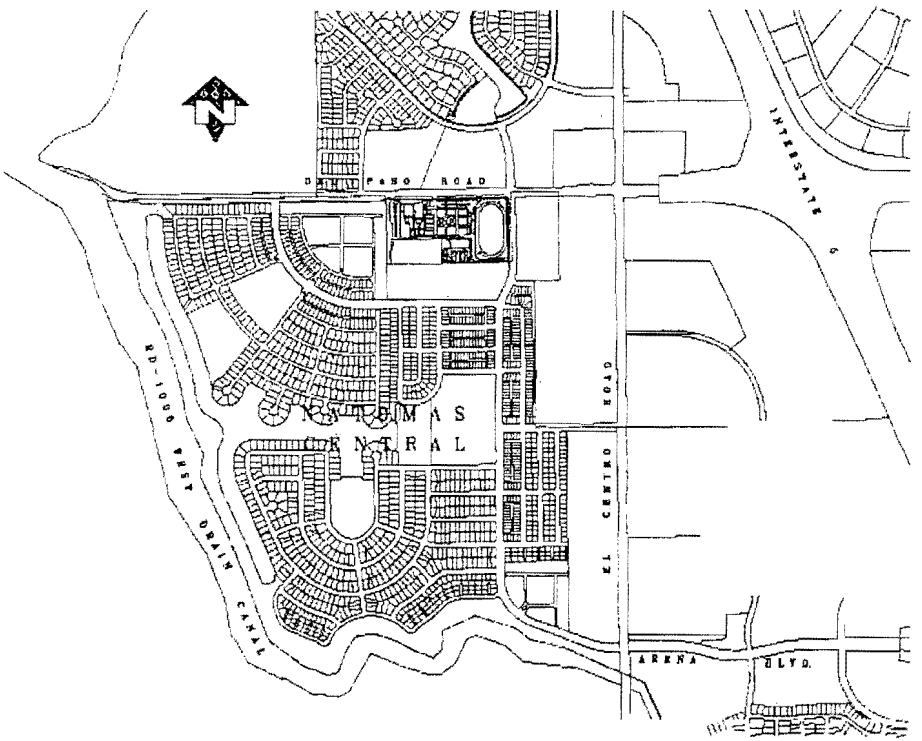


**Figure 2. Map of Natomas Central Development**

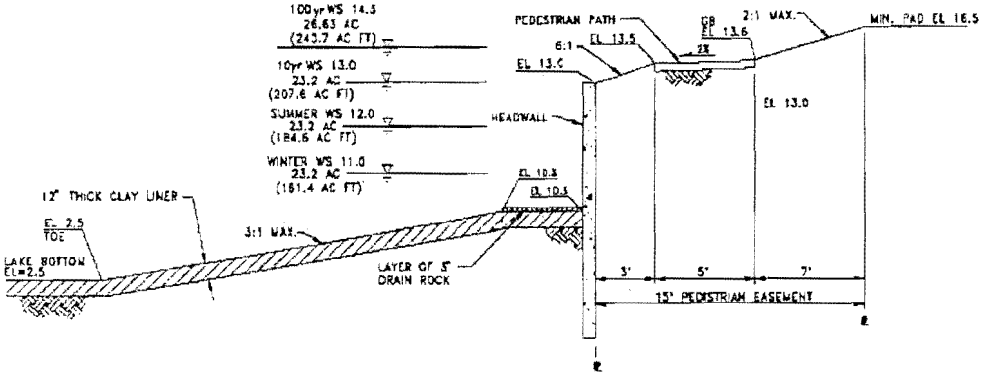


**Figure 3. Detail of Lake Perimeter Wall Elevations**

Lake water level will fluctuate with the seasons to permit damping of the winter runoff hydrograph and extend the detention time of water in winter. The summer surface water elevation will be 12 feet, and the winter elevation 11 feet, above mean sea level. Under typical conditions, the lake depth will vary from 8.5 feet (winter, no-flow condition) to 9.5 feet (summer). The lake volume in the summer and winter will be approximately 184.6 and 161.4 acre-feet, respectively. At maximum storage capacity, 14.3 feet above mean sea level (100-year), the accumulated lake volume will be approximately 240.7 acre-feet. Thus, the accumulated volume of the lake between the winter operating pool (11 feet msl) and the 100-year pool (14.3 feet msl) is approximately 79.3 acre-feet. The lake will be filled, and summer water level (12 feet above MSL) maintained, with groundwater drawn from a well located at the north end of the lake.

The surface water drainage system for the Natomas Central development will direct runoff into the lake at up to 11 major inlets. The inlets will be located in the arms of the lake, open space lots, at parks, and adjacent to the roads, which will assist in circulation during the runoff period. The distance between the nearest storm water inlet and the outlet of the lake is greater than 350 feet, which will limit "short-circuiting" of flow between the inlets and outlet and maximize pollutant removal efficiency. Outflow from the lake will discharge to the West Drainage Canal at a point west of the lake. The West Drainage Canal/Fisherman Lake flows into the Sacramento

River upstream of its confluence with the American River via the RD 1000 pump stations 3, 1A and 113.

Functioning of the lake for pollutant removal requires provision of adequate water detention time and proper design. During winter, the lake will provide storm water management and pollutant removal. The 10-year, 24-hour storm event, per SACPRE, is 2.95 inches in Zone 2 at elevation 16. This is approximately 102 acre-feet for the 415-acre drainage shed. Hydrologic flow estimates indicated that the maximum estimated storage volume of 125.3 acre-feet is sufficient to retain the entire 10-year, 24-hour storm. A more typical event is a water quality storm of 0.78 inches, which would result in an estimated runoff volume of 26.8 acre-feet.

The lake will be one component in a package of best management practices (BMPs) for water quality at the Natomas Central development. The lake will be managed as a vegetated, wet-pond system for treatment of urban runoff. Vegetated wet ponds are an effective water quality BMP. If properly maintained, vegetated wet ponds can achieve high removal rates for sediment, biological oxygen demand (BOD), organic nutrients, and trace metals. Biological processes within the lake also remove soluble nutrients, such as nitrates, ammonia, and orthophosphorus, which contribute to nutrient enrichment and eutrophication. Wet ponds are most cost-effective in large, intensively developed sites (Schuler 1987) like the Natomas Central development. Other BMPs that will contribute to water quality enhancement at Natomas Central include the use of landscape plants and maintenance that minimize water and fertilizer use; a public education program to raise awareness of how actions by individuals can contribute to water quality improvement or degradation; and applicable implementation of the City's comprehensive storm water management plan.

Wet ponds can remove pollutants effectively over long periods with appropriate maintenance. The primary mechanisms for pollutant removal are sedimentation and biological uptake. Sedimentation efficacy is primarily a function of detention time. Biological uptake is the primary removal pathway for soluble nutrients that have minimal settling rates. For wet ponds with a basin volume mean storm runoff volume ratio greater than 4.0, as expected under typical operating conditions at Natomas Central, estimated pollutant removal rates are greater than 80 to 90 percent for sediment, 60 to 65 percent for total phosphorus, 45 to 50 percent for total nitrogen, 40 to 45 percent for BOD, and 65 to 70 percent for many metals (U.S. EPA 1986, Sugnet and Associates 1997). Based on the Sato chart (Wood Rodgers, Inc. Drainage Master Plan, January 2006), a 415-acre shed area with an impervious value of 63%, requires a water quality storage volume of 26.8 acre- feet. The permanent pool has a minimum winter storage volume of 161.4 acre-feet, which exceeds the required Sato volume by a ratio of 6:1 (greater than 4.0).

Biological uptake of soluble nutrients and sedimentation in the lake will be enhanced by establishing rooted aquatic plants, or macrophytes, in the lake. Established stands of rooted aquatic plants in lakes can efficiently "scrub" nutrients and other pollutants from inflowing water. Numerous studies have documented that shallow lakes with aquatic plants have clearer water, with lower algae abundance than shallow, unvegetated lakes. Experience with other urban lakes in the Sacramento area has shown that vegetated lakes are more efficient in removing sediments from storm water than unvegetated lakes.

Vegetated wet ponds require periodic harvesting to maintain beneficial uses and optimal function. Excessive aquatic plant biomass often leads to diurnal fluctuations in dissolved oxygen concentration during summer when plant biomass and photosynthetic rate is highest. Plants raise dissolved oxygen concentrations during the day through photosynthesis, but consume dissolved oxygen during the night when they respire. Dissolved oxygen concentration during the early morning hours, after a night of respiration, can be quite low and lead to fish kills. In addition, surface mats of aquatic vegetation detract from the aesthetic appeal of lakes and often require management. Furthermore, as plant biomass accumulates, growth and pollutant sequestering slows because of self-shading.

*Expected Lake Water Quality and Biology*

The lake at Natomas Central is shallow and thermal stratification is not anticipated. If groundwater is undersaturated with dissolved oxygen, however, aeration may be required to meet the management objectives for the lake. Other groundwater-fed lakes in residential developments in the Sacramento area do not require aeration prior to discharge. If the lake is highly productive some transient dissolved oxygen depletion may occur and pH may be high during summer months.

Although no well-water chemistry is available, the typically high nutrient concentrations found in Central Valley groundwater can be expected to support abundant algae populations in the lake during the summer months. Experience with other vegetated wet ponds in the Sacramento area suggests that aquatic plants should grow well in the lake, however, establishment of populations capable of reducing nutrient concentrations low enough to limit algae growth may take two to four years. It is likely that some control of algae in the water will be required to meet management objectives (see below) during the period of macrophyte establishment.

Macrophytes must be harvested periodically from vegetated wet ponds to remove nutrients sequestered in the plants and to stimulate growth and additional nutrient uptake. Some species of macrophytes, such as Eurasian watermilfoil, Brazilian elodea, and Parrotsfeather, can establish high density stands that form surface mats and interfere with recreational and aesthetic uses of lakes. If these species become established, additional management will be required to maintain the lake.

Problems associated with runoff from residential lawns and streets (e.g., bacteria, grease and oils, pesticides, and sediment) will be minimized by use of the BMPs noted above.

## LAKE USES AND MANAGEMENT GOALS

Development of a lake management plan for a manmade lake, such as the lake at Natomas Central, is a four-step process. The initial step is to identify the uses of the lake and the water quality characteristics desired. In most cases, clear water, free of surface algae mats and aquatic macrophytes (rooted aquatic plants) are primary management goals. The second step is to identify existing or potential factors that could contribute to failure to meet the management goals. The third step is to develop a plan for minimizing water quality problems by reducing or

eliminating its causes. The fourth step is to develop a strategy for dealing with the nuisance organisms that proliferate when nutrient concentrations permit.

*Lake Uses*

The lake at Natomas Central is intended to provide aesthetic, storm water detention, water quality enhancement, and limited recreational benefits. Recreational use of the lake will be limited to non-gas motorized boating. No swimming or other water contact recreation will be permitted.

*Management Goals*

Management goals for a lake are based on the intended uses. Lake users and residents of the Natomas Central development will ultimately determine the desired condition and uses of the lake. All uses, however, must be consistent with, and subordinate to, the City's use of the lake as a flood control and water quality enhancement facility. If the uses identified above are adopted by the community, the following management goals will be adopted as narrative water quality standards:

- The lake should be free of surface mats of algae and macrophytes.
- Cyanobacteria blooms that could harm pets should be avoided.
- The lake should not produce nuisance odors.
- The lake will not contain concentrations of coliform bacteria associated with human wastes that exceed established water quality standards.
- The lake shall not contain floating material such as oil and grease, trash, scums, etc. that interfere with uses.
- Toxic materials that harm aquatic life or human health will not accumulate in the lake or be discharged from the lake.
- Outflow from the lake will not harm aquatic life in aquatic systems downstream from the discharge.
- The lake will be managed to reduce urban runoff and storm water runoff pollutants discharged from the outfall structure to the maximum extent practicable as determined by the City in accordance to its NPDES storm water permit and storm water management program.

Specific numeric lake management criteria are recommended as target values (Table 2). There is considerable uncertainty about the condition of the lake and development of the biological community after filling. It must be noted that the Natomas Central lake will take a number of years to reach a stable state. Processes such as final build out, formation and consolidation of

sediments, and introduction and establishment of biological communities will alter the condition of the lake and interact to influence future water quality. Monitoring will be required to assess the practicality of some of the management criteria.

**Table 2. Management Objectives for Water Quality in the Lake at Natomas Central**

| Constituent | Management Objective |
|---|---|
| Dissolved Oxygen* | 5 mg/L - mean monthly concentration<br>4 mg/L - single value |
| Clarity | 0.5 m Secchi depth - mean monthly value |
| pH** | 6.5-9 |
| Total Coliform Bacteria | 500/1100 MPN/100 mL[1] |
| Dissolved Inorganic Nitrogen[2] | 0.15 mg/L |
| Un-ionized ammonia | 0.02 mg/L - single value |
| Total Phosphorus | 0.05 mg/L - mean monthly concentration |
| Carlson's Trophic State Index*** | <60 |
| Chlorophyll | 0.015 mg/L - mean monthly concentration<br>0.04 mg/L - single value |

[1]Median value/90th percentile value
[2]Nitrate + Ammonia-nitrogen
* Measured in the morning
** Measured in the afternoon
$TSI_{Secchi}$ 60-14.41 x ln Secchi transparency (m)
$TSI_{Chl}$ = 9.81 x ln Chlorophyll *a* ($mg/m^3$) + 30.6
$TSI_p$ = 14.42 x ln Total Phosphorus ($mg/m^3$) + 4.15

In Lakeside Lake, another vegetated wet-pond urban storm water treatment facility, metals tend to be bound tightly to sediments and are not readily taken up by plants (Perry and Sytsma 1999). Accumulation of metals in vegetation is not anticipated; however, metals monitoring of water, plants, and sediment should be conducted to assess performance of the lake as a storm water treatment facility. Priority pollutant metals to be assayed include cadmium, chromium, copper, lead, nickel, and zinc. Criterion metals concentrations in water are shown in Table 3. Metals concentration in sediments and plants should not exceed hazardous threshold limits from Title 26.

**Table 3. Criterion Concentrations for Metals in Water (Hardness Expressed as mg $CaCO_3$/L)**

| | Continuous Concentration Criterion (:g/L) | Maximum Concentration Criterion (:g/L) |
|---|---|---|
| Cadmium | [e(0. 7852[ln(hardness)]-3.490)xO.85] | [e(1.128[ln(hardness)]-3.828)xO.85] |
| Chromium (III)[a,b] | [e(0.8190[ln(hardness)]-1.465)xO.85] | [e(0.8190[ln(hardness)]-3.688)xO.85] |
| Copper[a,b] | [e(0.8545[ln(hardness)]-1.465)xO.85] | [e(0.9422[ln(hardness)]-1.464)xO.85] |
| Lead[a,b] | [e(1.273[ln(hardness)]-4.705)xO.25] | [e(1.273[ln(hardness)}-1.460)xO.50] |
| Nickel[a,b] | [e(0.8460[ln(hardness)]-1.164)xO.85}] | [e(0.8460[ln(hardness)}-3.361 )xO.85] |
| Zinc[a,b] | [e(0.8473[ln(hardness)]-0.761 )xO.85 | [e(0.8473[ln(hardness)]-0.860)xO.85] |

[a]Values for aquatic life criteria are based on Quality Criteria for Water 1986 (USEPA 1987) as updated in US EPA (December 22, 1992). Criteria concentrations are expressed in terms of allowable dissolved metal following the US EPA Guidance Document on Dissolved Criteria-Expression of Aquatic Life Criteria- October 1993.

[b]Assumes a Water Effects Ratio (WER) of 1.0 until site specific data is obtained. Criterion Concentration = value in table x WER.

## MANAGEMENT PLAN

### *Best Management Practices (BMPs)*

Best Management Practices for water quality for the project should focus on prevention of water quality problems. BMPs that focus on water conservation, infiltration, nutrient loading, sediment management, and individual behaviors are listed in Table 4. Because of the aesthetic and nuisance concerns associated with the lake, the BMPs discussed in this Management Plan may be in addition to BMPs required by the City as part of the City's Stormwater Management Program.

Public education is critical to effective BMPs. Therefore, an informational program is recommended to provide residents of the development information on the management objectives, operation of the wet pond, and individual actions that can be taken to protect water quality in the lake.

**Table 4. BMPs for Protection of Natomas Central Lake**

Water conservation measures — reduce surface water runoff

- Check outside faucets for leaks.
- Mulch shrubs and other plants to retain soil moisture longer.
- Use trickle or drip irrigation whenever possible.
- Maintain lawn sprinklers to avoid "street watering."
- Water lawns less frequently but more deeply.
- Group plants with similar water requirements together.
- Use native plants that require less water.

Infiltration measures — allow water to enter the soil rather than runoff the surface

- Install porous pavement pavers.
- Direct downspouts onto lawns rather than to the street.

Nutrient management measures — less fertilizer used on lawns means less nutrients in the lake

- Apply fertilizers sparingly, never exceed label rates.
- Never dump lawn clippings and other materials into the water.
- Do not feed waterfowl; prevent a resident population from establishing.
- Clean up pet waste immediately.

Sediment management measures

- Sweep streets to prevent "wash off" into the lake.
- Maintain vegetated waterways to avoid erosion.
- Install silt screens around lake during construction.
- Incorporate sediment traps and oil and grease separators into storm drains.
- Use erosion control measures (silt screens, soil covers, etc.) during construction

Responsible chemical use

- Avoid using pesticides, herbicides, and fertilizers prior to predicted rainfall.
- Avoid over watering after applying fertilizers, herbicides, and pesticides.

Public Education

- Develop a public education program to inform residents and lake users about activities they can do to protect lake water quality.

*Waterfowl, Fish, and Plant Stocking*

Many BMPs implemented by residents and businesses in the development for little or no cost can be very effective in preventing serious water quality problems. Adoption of a prohibition on feeding of waterfowl, for example, can prevent serious water quality problems. Use of the lake by migratory waterfowl will add to the biological diversity and enhance the quality of the aesthetic experience of residents and visitors to the development. A large resident waterfowl population, however, can create management problems. A single duck can excrete 2.1 pounds of nitrogen and 1.3 pounds of soluble phosphorus each year. A population of several hundred resident ducks, which could easily develop on the lake, could be responsible for a significant portion of the nutrient loading to the lake. Resident waterfowl will destroy lakeside vegetation and contribute to erosion of lake banks. The most effective waterfowl management technique is to prevent development of large, resident populations. Residents should not stock domestic waterfowl, and should refrain from feeding wild, transient waterfowl. Uneaten feed will decompose in the water, which will add nutrients and create conditions conducive to the spread of avian botulism and fowl cholera. A restriction against feeding and stocking waterfowl will be incorporated into covenants.

Unauthorized introductions of all organisms should be policed by the Homeowners Association. Some fish species can also contribute to water quality problems through their feeding activities. Fish such as carp and goldfish should not be introduced by residents. Similarly, some aquatic plants can create a nuisance when introduced to a lake. A prohibition against fish and plant stocking will also be incorporated into covenants. Some stocking guidelines are:

- Residents will not release, or allow to be released, any fish, invertebrate, or plant into the lake

- All fish stocking, including original and any subsequent stocking, may be performed only with a permit from the California Department of Fish and Game. No fish species that require food supplements beyond existing sources in the lake will be permitted.

- Arrangements will be made as soon as possible after the lake is filled for the local mosquito abatement district to establish a population of mosquito fish *(Gambusia affinus)* for mosquito control. The lake will be restocked as necessary to maintain a population sufficient for vector control.

*Landscape Practices*

Landscape maintenance may also contribute to water quality problems in the lake. Over fertilization can lead to high nutrient concentrations in surface runoff that can stimulate phytoplankton growth and robust weeds resulting in the need for weed abatement. Landscape maintenance personnel often use a calcium-based, slow release fertilizer to reduce the labor of application. These fertilizers are spread liberally, and then the lawns are watered heavily to prevent burning. Under this application scenario, nutrient-rich runoff can enter storm drains and the lake causing algae to "bloom."

Landscape maintenance guidelines will be incorporated into covenants for the development as follows:

- Soil tests should be conducted to determine fertilizer requirements, if any. Fertilizer applications should be designed to alleviate deficiencies detected in soil tests. Commercial landscape companies should keep detailed records of test results, application dates and rates, and irrigation schedule.

- Nitrogen fertilizers should not be applied at rates greater than 0.5 pounds per 1,000 square feet and at frequencies greater than every 12 weeks.

- Phosphorus fertilizers should not be applied unless a need is clearly demonstrated, such as the first growing season for newly established turf areas. In no case should the rate exceed 0.05 pounds per 1,000 square feet.

- Fertilizers, pesticides, and herbicides should not be applied prior to predicted rain events.

- Fertilizer, pesticide, and herbicide application methods should not enter lake water directly.

- There should be no application of fertilizer to drainage ditches, seasonal dry waterways, impervious surfaces, or within 10 feet of the water.

- Irrigation schedules should be designed to prevent runoff from freshly fertilized landscape.

- Landscape contractors should be required to provide at least five days written notice to the Homeowners Association for fertilizer and significant herbicide and insecticide application. The notice should include justification for the action (e.g., copy of soil test report) and a description of rates, application methods and time including precautions to prevent pollution of surface waters, the materials to be applied.

- Disposal of leaves and other organic debris into the lake and/or other waterways (even seasonally dry waterways) should be avoided. Disposal of organic debris in water has several detrimental results. They can cause oxygen depletion when they

decompose and they contribute nutrients to the lake water that can stimulate algae growth. Curbside stockpiling of leaves and other "green" waste should be done on the street side of the gutter flow line.

- Landscape planting should avoid use of deciduous trees or shrubs greater than four feet in height when mature within 15 feet of the shoreline to avoid leaf fall into the lake.

*Sediment Control*

Whenever vegetation is removed from an area, e.g., for construction, preparation for new landscaping, after a fire, etc., the potential for soil erosion and sediment deposition in the lake exists. Sediment deposition in the lake has several undesirable effects. It can reduce light penetration through the water causing beneficial aquatic plants to die. Sediment also carries substantial amounts of nutrients with it, which can contribute to algae growth when the water clears. Lastly, over the long-term, sediment deposition causes the lake to become more shallow, warmer, and more productive, i.e., with more algae and nuisance aquatic plant problems. To minimize erosion and sediment deposition in the lake, all excavation within the watershed should be done in accordance with the City of Sacramento's Grading and Erosion Control ordinance and National Pollutant Discharge Elimination System (NPDES) permit.

Whatever the method of implementation, through covenants or by voluntary adoption, residents of the Natomas Central development should be aware of the impacts of their activities on the lake. An aware and informed community is a prerequisite to effective lake management. Signs or an information program that describes the organisms and functioning of the lake and encourages voluntary adoption of BMPs to protect the lake is recommended. Potential subjects for information program include:

- Description and explanation of landscape maintenance guidelines.
- Proper disposal of automotive fluids, cleaning detergents and other wastes.
- Problems caused by resident waterfowl and prohibition against feeding.
- Problems caused by exotic fish and prohibition against stocking.
- Explanation of lake functions as a storm water treatment facility and overall goals of the lake management plan.

## MANAGEMENT OF ALGAE AND ROOTED AQUATIC VEGETATION

Even with well-implemented BMPs, nutrients in the groundwater used to maintain lake level in the summer may support abundant algae in the lake during the first two to three years after filling. Following establishment of aquatic vegetation, algae problems should be minimal. Some form of treatment is likely to be required to meet management objectives immediately after filling. As noted above, the most effective way to prevent algae growth in the lake is to limit the amount of nutrients entering the lake. Management strategies to reduce nutrient loading when the water supply is from groundwater, however, are limited. Nutrient concentration in the inflow could be reduced by treatment of the water prior to discharge into the lake, or treatment of the entire lake, with aluminum sulfate (alum). This management strategy is expensive and when water is treated prior to discharge into the lake a sludge must be disposed. Nutrient precipitation prior to discharge into the lake is not recommended at this time.

Some form of in-lake algae treatment may be required to meet the management objectives of the lake during the summer months. The amount of algae in the lake can be reduced by hydrologic, physical, and chemical techniques. Whole lake treatment with alum can provide temporary improvement of water quality, and if algae problems are persistent and difficult to manage with other techniques (see below) a whole lake treatment should be considered. The flushing rate of the lake should be maximized to reduce algae abundance in the lake.

Excessive algae can also be treated with a number of effective algaecides. Various forms of copper have no restrictions on water-use following application, however, the City and State may have use restrictions that differ from those on the label. Copper should be used to control excessive algae in the lake if surface algae scums develop or use is degraded. Copper may injure rooted aquatic plants, however, selection of the correct formulation and dose by a licensed aquatic applicator should permit control of algae with minimal to no effect on rooted plants.

The City can pre-approve all chemical applications. The City's water quality requirements have priority over algae control in the lake, and these requirements may limit the use of copper for algae control. If copper applications result in copper concentrations at the discharge point that are greater than at other wet pond discharges in North Natomas, alternative *(e.g.,* alum treatment) or no algae control must be considered.

Rooted aquatic plants will require periodic harvesting to remove sequestered nutrients and other pollutants. Harvesting will be implemented to remove surface mats and nutrient pollutants (e.g., phosphorus and nitrogen) from the system. A minimum of two macrophyte harvests are recommended. The first harvest, in July would be conducted to remove nitrogen and phosphorus and to stimulate additional growth and nutrient uptake. A second harvest should occur in fall to remove accumulated nutrients before the plants senesce and they are released back into the water. If nuisance, invasive plants are introduced to the lake additional harvesting and selective herbicide applications may be necessary to meet management objectives. As noted above, if the Natomas Central Lake performs as other similar treatment facilities, metals accumulation in plants is not anticipated; however, plants samples should be collected for metals analyses to document metal concentrations prior to harvest and disposal. Harvested plants should be disposed of in a composting facility.

Rooted aquatic plant problems may be avoided if introduction of the problem plants can be prevented. As noted above, some exotic plants, like Eurasian watermilfoil, are particularly troublesome. Every effort should be made to prevent the introduction of these nuisance aquatic plants into the lake. All boats launched in the lake, which have been used in other lakes during the previous two weeks should be inspected for plant fragments that could cause weed problems. This could be a voluntary inspection stimulated by a sign posted at the boat ramp. The sign should also warn residents of the danger of introducing aquarium fish and plants to the lake.

## MANAGEMENT OF TRASH AND LITTER

Trash and litter problems can be limited by assuring that adequate numbers of trash receptacles are available and that they are emptied regularly. Trash and litter on the lake may be collected by hand by residents or the service may be purchased from a lake management company.

## MANAGEMENT OF WATER QUALITY

The water quality criteria are intended as a guide for maintenance of water quality that will meet the management goals for the lake. These criteria are intended to serve as warning signs for significant water quality problems. Consequently, a single exceedence of any water quality parameter will not necessitate an immediate change in the management plan. If water quality fails to meet the criteria regularly the City, the Homeowners Association, and water quality and lake management experts should evaluate the consequences and impacts of continued exceedence. If it is determined that serious harm to aquatic life in and downstream from the lake will occur, or if regulatory thresholds are exceeded, an in-depth evaluation of the lake and management plan will be necessary. Some possible responses to exceedence of specific water quality criteria are shown in Table 5.

**Table 5. Potential Response to Selected Examples of Unacceptable Water Quality**

| Parameter | Management Response |
|---|---|
| pH | Identify cause as short-term or persistent<br>Calculate rate of loss of available carbonates<br>Take action to eliminate source or compensate for carbonate loss |
| Dissolved Oxygen | Identify cause of dissolved oxygen depletion and eliminate<br>Consider installation of recirculation/aeration system |
| Nitrate-nitrogen | Examine landscape maintenance practices<br>Evaluate other potential sources<br>Eliminate sources |
| Ammonia-nitrogen | Examine landscape practices<br>Evaluate in-lake sources (ammonification of organic |

| | |
|---|---|
| | materials)<br>Consider aeration to increase nitrification |
| Phosphorus | Examine landscape practices<br>Evaluate other sources<br>Eliminate sources<br>Anticipate phytoplankton blooms and prepare for Treatment |
| Chlorophyll *a* | Evaluate nutrient concentrations<br>Take action to reduce nutrient concentration |
| Oil and grease | Locate source; prevent remaining reservoir from entering lake<br>Identify reason source was created and prevent Recurrence<br>If concentrations are high enough to endanger aquatic life contact RWQCB and CDFG for assistance |
| Coliform bacteria | Post notices<br>Identify source and eliminate<br>Further testing of more specific bacteria such as E. Coli, Fecal Coliform, or Enterococcus |

## MONITORING

All lake management plans must be adaptive; changes may be required as lake biology and water chemistry evolve. Regular monitoring of lake water quality permits ongoing assessment of the efficacy of the management plan and allows adaptation to changes in the lake.

Monitoring should be an integral part of the management plan. A monitoring program should provide data needed to understand the biological and chemical characteristics of the lake. Some of the monitoring effort may be conducted by interested, well-trained lake shore residents or the service may be purchased from a lake management company. However the data is obtained, it must be incorporated into the management effort to ensure that the management plan is adaptive and effective. Monitoring should include measurement of lake level, water transparency, temperature and dissolved oxygen profiles, pH, nutrients, chlorophyll, suspended solids, and coliform bacteria.

Recommended monitoring parameters are shown in Table 6. Sampling locations are shown in Figure 4. A minimum of quarterly sampling is recommended.

**Table 6. Frequency, Sample Type, and Number of Stations for Monitoring Water Quality in Natomas Central Lake**

| Parameter | Frequency | Sample Type | Stations |
|---|---|---|---|
| Water level | weekly in winter biweekly in summer | staff gauge | overflow weir |
| Temperature | quarterly | profile | 3 |
| Dissolved oxygen | quarterly | profile | 3 |
| pH | quarterly | profile | 3 |
| Specific conductance | quarterly | profile | 3 |
| Alkalinity | quarterly | depth integrated composite | 1 |
| Hardness | quarterly | depth integrated composite | 1 |
| TOC | quarterly | depth integrated composite | 1 |
| Chlorophyll a | quarterly | depth integrated composite | 1 |
| Phytoplankton | quarterly | depth integrated composite | 1 |
| OP pesticides | quarterly | depth integrated composite | 1 |
| Bacteria | quarterly | grab | 3 |
| Nutrients | quarterly | depth integrated composite | 1 |
| Suspended Solids | quarterly | depth integrated composite | 1 |
| Sediment Metals | annual | grab | 2* |
| Plant Metals | prior to harvests | composite | 6** |

*separate composite samples will be collected from arm and main lake stations to assess localization of pollutants near inflows.

**plant samples for metal analyses will be collected from three main lake basin stations and three additional near-shore stations. Samples will be composited for analysis.

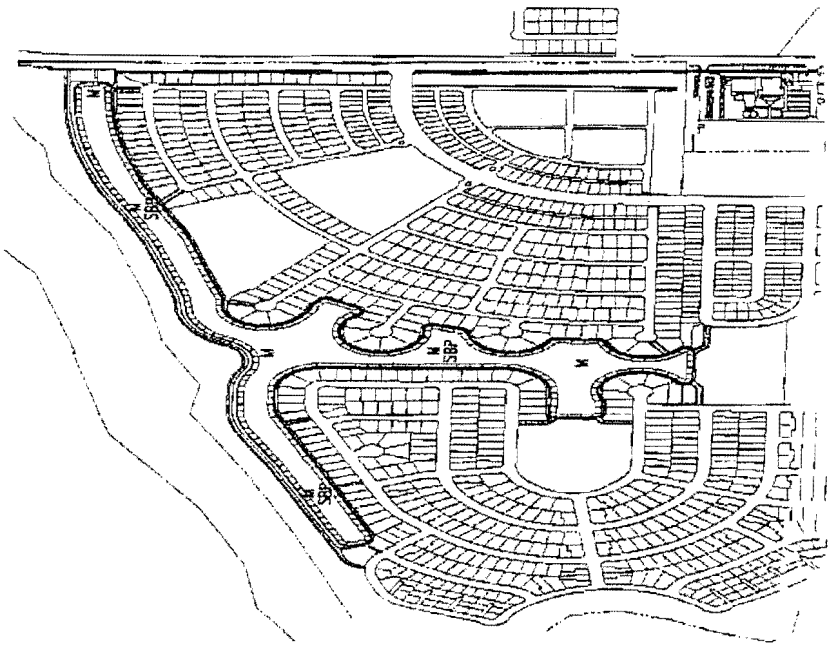

**Figure 4. Approximate Location of Natomas Central Lake Sampling Stations. (M=macrophyte metals, P=profile, B=bacteria, S=sediment metals)**

## MANAGEMENT COST ESTIMATE

Prediction of the condition of the lake prior to filling provides only a limited picture of the potential management problems that may be encountered. Estimated lake management costs are based upon expected conditions in the lake and are based upon the need to maintain the lake as an aesthetic amenity in a condition that will not impede flood control or cause water quality impairments or violations downstream of the discharge point. Certain activities are sure to be required including monitoring, algae control, plant harvesting, and trash cleanup. Preventive actions for waterfowl and aquatic weed problems, such as signs and fliers that discourage feeding of waterfowl and introduction of fish and aquatic plants as discussed above, will be incorporated into CC&Rs.

Monitoring of water quality will be conducted. Summer sampling will provide information required for more informed management decisions. The monitoring program should include regular examination of the watershed of the lake to identify activities that could contribute to water quality degradation, such as improper landscape maintenance. Regular monitoring of the lake will facilitate early identification of problems and permit rapid correction of potential detrimental activities.

Management actions depend upon the conditions that develop in the lake and the management objectives determined by the homeowners. Some form of control, however, is likely to be necessary to meet the objectives for the lake. The extent and duration of summer algae problems are unknown at this time and the need for aquatic plant harvesting is a function of the plant growth rate and efficacy of the weed introduction prevention program discussed above. If algae are a problem, they may be controlled with proper copper application, chemical precipitation of nutrients in well-water, more efficient mixing, and/or alteration of system hydrology. Chemical control with an appropriate copper application is recommended and budgeted; however, any chemical application for algae control can first be approved by the City.

Trash cleanup by a professional lake management firm twice per month is budgeted to control litter.

Estimated management costs are shown in Table 7. Actual management costs will depend upon severity and frequency of algae and aquatic plant problems, which are a function of the efficacy of the prevention program for aquatic weeds and waterfowl. A 20 percent contingency is included in the budget for the first year to accommodate any changes in the Plan mandated by the City of Sacramento for flood control and/or water quality purposes. Such changes shall be at the discretion of the Department of Utilities. An Annual Report will be produced that summarizes management activities and limnological characteristics of the lake. Limnological characteristics and management problems in the lake will likely change as the lake ages. The Annual Report will also include recommendations on changes to the Management Plan so that the management of the lake will adapt to changing conditions. Any changes to the Plan must be approved by the City.

**Table 7. Estimated Cost of Management Plan During First Year**

| | |
|---|---|
| Task 1. Monitoring | |
| Sampling | $ 4,000 |
| Laboratory analyses | $12,000 |
| | $16,000 |
| Task 2. Public Education Program | $ 500 |
| Task 3. Twice/month Trash Clean up | $ 4,000 |
| Task 4. Establish/Maintain Vegetation | $ 11,500 |
| Task 5. Algae Control | $ 5,700 |
| Task 7. Quarterly and Annual Reports | $ 8,000 |
| | $45,700 |
| Contingency (20%) | $ 9,140 |
| Total Cost | $54,840 |

ROLES AND RESPONSIBILITIES

It is the responsibility of the homeowners association to fund and implement the activities outlined in this Plan, and to maintain the lake in a condition that permits functioning as a flood control and water quality enhancement facility. It will not be the responsibility of the City of Sacramento to maintain the aesthetic appearance of the lake or manage nuisance conditions that may develop in the lake, e.g., trash buildup within the lake. The homeowner's association and the City will, however, work cooperatively on public education and enforcement of best management practices to maintain water quality and the aesthetic value of the lake. The City of Sacramento will do the following:

- Maintain inlets to the lake and the outlet structure as needed to provide drainage and flood control.
- Regulate the operations and maintenance of the lake to assure compliance with Federal, State, and local water quality requirements.
- Determine if the homeowners association is maintaining the lake in a manner consistent with the City's flood control and/or water quality standards and take actions necessary to remedy any deficiencies if City standards are not met. The City may charge the homeowner's association for costs of remedial actions.

# REFERENCES

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Schueler, T.R., "Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs," Metropolitan Washington Council of Governments, Washington D.C., 1987.

Perry, Stuart and M.D. Sytsma, "Lakeside Water Quality Compliance Monitoring Report," prepared for County of Sacramento, 1999.

Sugnet and Associates, "Technical Basis for Water Quality Treatment Criteria," prepared for City of Sacramento, 1997.

US EPA, "Methodology for Analysis of Detention Basins and Control of Urban Runoff Quality," Nonpoint Source Branch, Office of Water. EPA-440-5-87-001. 51 pp., 1986.

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Wallace-Kuhl and Associates, "Natomas Central Lake Supplemental Geotechnical Engineering Report," WKA No. 5766.02, 2005.

Welch, E.B., "Ecological Effects of Wastewater," *Cambridge University Press.* Oxford. 337 pg., 1980.

Wood Rodgers, Inc., "Natomas Central Drainage Master Plan," January 2006.

EXHIBIT "D"

Maintenance Responsibilities of Owner

1. Provide makeup water as required to maintain lake water surface elevation and pay all costs (e.g. pumping) for makeup water.

2. Provide water to fill lake after lake is drained for repairs and/or maintenance and pay all costs associated with filling lake.

3. Repair leaks in the lake liner.

4. Dredge lake to maintain water quality and flood control operation.

5. Maintain and repair bulkhead and associated lake side-slopes on the water side and land side of the lake.

6. Perform all measures as specified in the City-approved Lake Management Plan, attached to this Agreement as Exhibit C, including any City-approved modifications.



CITY
AGREEMENT NO. 2006-0383