Report of the Beaver Subcommittee To the Martinez City Council

April 16, 2008

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HYDROLOGY/FLOOD MANAGEMENT

PERSPECTIVE #1

Issue Definition/Problem Statement

Flood protection improvements were constructed in Alhambra Creek in the vicinity of the beaver dam in 1999. Philip Williams Associates (PWA) conducted an investigation of the beaver dam and its impact on Creek flows and prepared a report dated October 16, 2007. The Creek channel has an approximate capacity to convey a 10 year frequency storm (a storm that has a 10% chance of occurring in any given year). The bridge at Marina Vista is also a controlling factor for flood conveyance and provides approximately the same capacity as a 10 year storm.

The beaver dam reduces the flow capacity of the Creek and can cause the Creek to overflow in a lower frequency storm than its capacity for a 10 year frequency storm. The amount of reduction in storm flow capacity depends on the height of the dam. If the watershed produces a storm runoff in excess of 10 years, then this section of the Creek will flood whether the beaver dam is present or not.

Objectives and Assumptions

The objective is to determine options for providing the same level of flood protection with the beaver dam as the channel provided before the dam was constructed. Equal value is placed upon flood protection and eco-system habitat. However, flood protection for the community is ultimately a paramount consideration.

In a natural system, a beaver dam will sometimes be washed out or partially washed out in a large storm. Since this is not guaranteed and since the consequence of flooding is so great, it is assumed in this report that the dam will remain in place during a storm and the flood response planned for accordingly.

It should be noted that the October 16, 2007 PWA report is based on a beaver dam that is six feet in height. In early January, 2008, the City and Skip Lisle constructed a pond leveling device and lowered the dam. The pond leveling device maintains the dam height at the current height which is less than six feet. In a March 18, 2008 report, PWA evaluated dam heights of 5 feet, 4 feet and 3 feet (reduced dam heights of one, two and three feet). (Attachment A.)

The options below are based on the PWA reports which indicate flood flows in the Creek would be approximately two feet higher with a six foot beaver dam and one foot higher with a four foot dam. This is shown on Figure 7 in the March 18, 2008 report for a 7 year storm and Figure 6 in the October 16, 2007 report for a 10 year storm. The pond leveling device attempts to insure a stable dam height and, in fact, the height has remained constant since it was installed. The current dam height is assumed to be two feet lower than the six foot dam height in the October 16, 2007 report. The options below are described assuming a four foot dam height and information presented in the March 18, 2008 PWA report (beaver dam minus 2 feet).

Alhambra Creek had a 2 year storm capacity in the downtown area before the flood control improvements were constructed. That has been improved to a 10 year capacity. The current capacity of the Creek system upstream of the flood control improvements is not known, but it is assumed that the Creek system will convey a 10 year storm to the reach of Creek where the beaver dam is located.

Options

The following options for providing flood protection meet the objectives:

1) **Emergency Dam Removal** – *This is a short term option that should be kept in place until a longer term solution has been identified and implemented*. However, it is also possible to maintain this option (status quo option) for a longer period of time.

   The City has installed anchors in the dam with cables that can be pulled to remove the dam within a very short time period. This would be implemented under established protocol by the City.

   An interesting side note is that during a storm greater than a 10 year frequency, removing the dam will not result in any overall reduction in flood damage to the surrounding area, although the flood flows would over-top the Creek banks sooner with a dam in place than without a dam. However, storm systems and the exact track of a storm cell are very difficult to predict. It is almost impossible to determine the storm frequency at a particular location in advance or during a storm event with any accuracy. Following current protocols, it is assumed the dam would be removed prior to 10 year frequency flows.

2) **Flood Terrace Expansion** – *This option is to excavate a flood terrace on the west bank in the vicinity of the dam to provide equivalent flood capacity to that lost by the dam construction.*

   Widening of the flood terrace is constrained by the existing sidewalk and the width of any potential rip rap slope protection installed on the bank of the newly constructed flood terrace. The west bank excavation would begin downstream of the Escobar Street bridge and extend down to just before the Marina Vista bridge. The flood terrace would accommodate storm waters during high flow events. When a storm exceeds a 10 year frequency, then the flood terrace and the channel capacity would be exceeded.

3) **Bypass Pipe** – *This option would construct a pipe with an entrance upstream of the dam and an outlet downstream of the dam.*

   The inlet of the pipe could not receive waters from the pond, as that would disrupt the pond elevation upstream of the dam. As a result, there would need to be an inlet structure of some type to control storm flows going into the bypass pipe. The bypass pipe would have to be installed within the adjacent Creek bank and construction costs would be very high. The pipe would have to be sized to convey the flow capacity lost by the beaver dam. This option would have the same benefit yet cost much more than the flood terrace option.

4) **Flood Wall/Flood Berm** – *This option would construct a flood wall or flood berm along the west bank of the Creek between Marina Vista and Escobar Street, and a*

flood wall between Escobar Street and the back of the buildings on Main Street just upstream of Escobar Street.

According to the hydraulic modeling done by PWA, the west bank would need to be elevated approximately 1 foot between Marina Vista and Escobar streets to accommodate the increased height of flood waters in a 7 year storm event. The building along the east bank would also need protection from the increased flow height. This could be accomplished by constructing a short one foot high masonry block wall from the end of the wall at the back of Bertola's to Marina Vista. Upstream of Escobar Street, the gap in the masonry block wall on the east bank would have to be closed. The wall would need to be extended from its current end and tie into the Escobar Street bridge. The bank on the west side of the Creek, upstream of Escobar Street, would also need to be raised by constructing a tapered flood wall or increasing the height of the existing rock revetment. The flood wall or revetment would be tapered from a height of 2 feet at the Escobar bridge to zero at a point about 30 feet upstream.

It should be noted that if the flood walls above were increased from one foot to two feet in height, they would contain flood flows for a 10 year storm with a 6 feet high beaver dam.

5) **Detention Basin** – *This option would construct a detention basin upsteam to offset the loss in capacity of the beaver dam.*

If a larger basin was built, it would provide enhanced flood protection for the downtown than it had prior to the beaver dam. In addition, enhanced flood protection would be provided for the entire portion of the watershed downstream of the basin.

6) **Flood Terrace/Flood Wall Combination** -- *This option is a combination of options 2 and 4 above*.

This would construct a flood wall and/or flood terrace along the west bank of the Creek between Marina Vista and Escobar Street, and a flood wall on both sides of the Creek (as described in Option 4) between Escobar Street and the back of the buildings on Main Street just upstream of Escobar Street. The building along the east bank would also need protection from the increased flow height. This could be accomplished by constructing a short one foot high masonry block wall from the end of the wall at the back of Bertola's to Marina Vista.

It should be noted that a flood terrace by the dam shares the same space as a flood berm. So the width of a flood terrace proposed on the west bank by the dam narrows the width available for a flood berm by the same amount. For this reason, a flood berm in the vicinity of the dam won't work in the combination option.

7) **Controlled Overland Release** – *This option would allow the Creek to overflow in a designated location where the path of flood flows are predictable and create no damage to private property*.

One possible flow route is a release near the dam just upstream of Marina Vista. The flood waters would currently flow down Castro Street north to Marina Vista, then west on Marina Vista and north on Alhambra Avenue and enter the Creek at Alhambra and Buckley Street. An improved overland release option would be to direct the overland flows from Castro Street into the Creek just downstream of the

Marina Vista bridge. This would entail reconstructing the Marina Vista road section and north sidewalk for 50 feet, just west of Castro Street. This would result in a depressed road section or, "valley gutter", across Marina Vista to the park. The waters would be directed across the park in a broad swale to the Creek between the Marina Vista bridge and the pedestrian bridge. The Creek would need to be armored with rip rap at the re-entry point.

To further enhance this option, Castro Street could be modified to drain to the north. Currently the low point in the street is south of the intersection. To drain the low point of Castro Street would require lowering the southwest curb return of Castro Street and Marina Vista by about 9 inches. If the curb return is not lowered then ponding would occur in Castro Street for approximately the length of the block.

It should be noted that in large storms, Alhambra Creek overflows upstream of downtown with stormwaters flowing down Castro Street and Alhambra Avenue, and stormwaters from the eastern hills drain down Berrellesa Street and all converging in this same general area of Marina Vista/Alhambra/Castro.

Fiscal Impact

1) **Emergency Dam Removal**

- *Capital Costs* – The City has already installed the anchors and cables.
- *Maintenance Costs* – Ongoing staff costs at approximately $2000 for each significant storm event.
- *Funding Source* – City
- *Timeline* – Currently in place.

2) **Flood Terrace Expansion**

- *Capital costs* – The flood terrace outlined in the PWA report includes excavation, rock revetment, handrail, transitions and riparian plantings ($50,000 - $100,000).
- *Maintenance costs* – Very little ongoing costs.
- *Fund source* – City, grants
- *Timeline* – One year to two years to plan, develop, design and permit a project.

3) **Bypass Pipe**

- *Capital costs* – Need more information to accurately determine pipe size and estimate costs. However, increasing the flood flows by one foot is approximately 55 square foot of cross sectional area at the Beaver Dam. Setting aside fluid pipe dynamics and head losses, just to convey 55 square foot of flow area would result in approximately an 8 foot diameter pipe. This alternative would probably be cost prohibitive. In addition, it

would be almost impossible to fit a bypass pipe in the area available.

- *Maintenance costs* – Pipe systems are relatively maintenance free. Assuming the inlet structure has a trash rack, it would have to be cleaned twice a year, on average, and the system inspected once a year. Estimated cost $15,000 per year.

- *Fund source* – City

- *Timeline* – One year to two years to plan, develop, design and permit a project.

4) **Flood Wall/Flood Berm**

- *Capital costs* – Installing a one foot high berm between Marina Vista and Escobar Street ($20,000). Installing a one foot high masonry block wall on the east bank from Bertola's to Marina Vista ($10,000). Extending masonry block wall on east bank on the south side of the Escobar Street bridge ($1,000 - $3,000). Raising elevation of stone wall on west bank south of Escobar Street ($5,000 - $10,000).

- *Maintenance costs* – No increased maintenance costs to existing facilities along the Creek.

- *Funding source* – City, grants.

- *Timeline* – Four months if conducted as a maintenance project, one year if constructed as a capital project.

5) **Detention Basin**

- *Capital costs* – Depends on basin size and location.

- *Maintenance costs* – Similar to Nancy Boyd Creek Detention Basin

- *Funding source* – City, developer fees if stormwater treatment and/or hydrograph management is included, grants.

- *Timeline* – Two to three years to acquire property and plan, develop, design and permit a project.

6) **Flood Terrace/Flood Wall Combination**

- *Capital costs* – Installing a wall/terrace combination between Marina Vista and Escobar Street ($20,000 - $50,000). Installing a one foot high masonry block wall on the east bank behind Bertola's to Marina Vista ($10,000). Extending masonry block wall on east bank, just south of Escobar Street ($10,000). Raising elevation of stone wall on west bank just south of Escobar Street ($5,000 - $10,000).

- *Maintenance costs* – No increased maintenance costs to existing facilities along the Creek.

- *Funding source* – City, grants.

- *Timeline* – Four months if conducted as a maintenance project, one year if constructed as a capital project.

7) **Controlled Overland Release**

- *Capital costs* – Reconstruct 50 feet of Marina Vista pavement and north sidewalk ($40,000). Re-grade park and install Creek revetment ($20,000). Reconstruct curb return ($10,000).

- *Maintenance costs* – Sediment clean-up costs after a storm. Sediment build up would be less if the curb return is lowered and Castro drains to the north.

- *Funding source* – City, grants.

- *Timeline* – One to two years to plan, develop, design and permit a project.

It should be noted that implementing some options would have system-wide benefits, while others only have localized benefit.

PERSPECTIVE #2

The following is a response to the City's Hydrology report.

The beaver dam is not static as depicted in the report. It lowers in proportion to the strength to the pre-flood flows. **The dam was actually washed out during a flow of about one half volume of the Creek on January 26, 2008.**

The bridge volumes above and below the dam are very close to the volumes over the dam. This is especially so if the measurements of the dam are verified and based on the 3 ft. dam that was determined safe by the City. **When tides are up to the 3 ft. height of the dam or above, the lower bridge becomes the restricting factor of the Creek.**

The Creek bed at the dam location should be re-measured as the Creek bed is being counted as the beaver dam. This adds to the idea that the dam has greater restricting value.

There are ways to increase the volume of the Creek adjacent to the dam location. One is removing some of the bank on the street side. There are about one and one half 3 ft. dam volumes gained by doing so. This depends on the volume of the bank removed, height and width. **The bank elevation removed would create a flow path above the high tide elevations as well.**

Treatments to the Creek in terms of flood improvements are needed regardless of the beavers' presence.

The fact the dam washes out negates the Hydrology issues, as does the removal cable.

The flow device has been a good tool to create comfort zone, a larger buffer, it can be adjusted in non rain times to create a higher creek. High tide would be a good constant during non-rain cycles.

An outline of the Creek flow and the beaver dam: A heavy flow pre-flood will compromise the dam in proportion to the volume of the flow. More than likely the dam will be pushed away naturally by a pre-flood flow, but the two high tides a day are somewhat static. They are there until they recede, not giving way.

A dam breach during a heavy flow will be gradual, so to speak. There will be water flowing over the dam and equalizing on the lower side and especially so on a high tide cycle. This will have little impact to the downstream area, only a mixing of water from both sides of the dam. On this heavy flow the debris will wash out to the Bay on low or high tide.

Something else to take into account is that the material on the dam is wood and mud. The wood is buoyant, so it will tend to float up as well.

Lowering the dam could wait but there is no harm done as long as it is only a foot, as beaver can handle that. It does interfere with being scientific, in that if we waited we could actually see the strength or weakness on the dam.

The backup break away plan will protect us from beaver-related flooding. It should be noted that everything in the Creek now was there before and possibly less, just rearranged.

Please see the "Beaver Dam Information Site," pages 1-4. (Attachment B.)

Please see attached page 110 of The Beaver Natural History of the Wetlands Engineer by Deitland Muller-Schwarze and Lixing Sun. (Attachment C.)

WATER QUALITY

PERSPECTIVE #1: SUMMARY

The reach of Alhambra Creek between Ward and Main Streets is especially visible and has been reported to become "murky" with visible floating aquatic vegetation. These properties are aesthetic, rather than public health issues, but can produce an effect on the attractiveness of the area.

Although, in general, the presence of beavers is associated with improved, rather than impaired water quality, arguments have been made associating the unattractiveness of this reach in late summer with the presence of beavers. Other arguments have been made that the configuration of this reach makes it vulnerable to late-summer unattractiveness regardless of the presence or absence of the beavers.

A plan is proposed to evaluate the extent of the perceived problem and to determine if it is related to the presence of the beavers or is inherent in the characteristics of the Creek.

Water Quality Issues

Alhambra Creek is a stream whose flow varies a great deal from season to season. In late summer and fall, the flows are at their lowest. During this season, the water of Alhambra Creek naturally warms up. It also contains a significant amount of organic matter and nutrients. Alhambra Creek receives nutrients from urban runoff, containing such materials as nitrates and phosphates. These come from failed/leaking septic systems, illicit grey water, storm drains which route run-off such as excess fertilizer from lawns and playing fields, and detergents from car washing directly into the Creek. With lower flow, nutrients present in the water become more concentrated.

Warmer temperature and more concentrated nutrients favor growth of aquatic vegetation and accelerate the decomposition process. Warmer water also reduces the solubility of oxygen in water. Accelerated decomposition of organic material further depletes the dissolved oxygen. An environment that is depleted of oxygen is known as "anaerobic". Anaerobic decomposition breaks down organic material into very fine particles which can be suspended in the water and decrease clarity. It can also result in the emission of unattractive-smelling gases.

Fecal bacteria are associated with the presence of animal and human waste. Some typical sources are sewer/septic leaks, animal waste swept or washed into the stream from surrounding surfaces, direct defecation into the water by humans or animals, and defecation by wildlife. Bacterial levels are not static. Once bacteria are introduce, if the conditions are favorable, their populations can grow at very high rates. Numerous tests have shown that Alhambra Creek water contains fecal bacteria. The levels go up in the summer and go down in the winter. The same conditions that reduce dissolved oxygen also promote bacterial growth.

The aesthetic aspect of water quality is also evident during these warm, low-flow times. The perceived diminished attractiveness of the Creek for some visitors during this time is typically attributed to two factors: the turbidity of the water and the presence of unattractive aquatic vegetation growth in the water. The turbidity of the water during low-flow periods is usually not due to suspended sediment but to an accumulation of suspended organic material. Increases in organic material are promoted by an abundance of nutrients, by higher temperatures and by diminished flow. In relatively extreme conditions, unattractive odors can be released by warm, organically laden, nutrient rich water, further diminishing the attractiveness of the stream.

These conditions exist wherever the water is still, deep and warm. Pools above and below the beaver-created impoundment, as well as the impoundment itself, meet these criteria. The beaver-created impoundment has one potential advantage over the other pools: the water exits the beaver pond from the bottom via the leveling device, while the non-beaver pools exit at or near the surface. This may create a more favorable flushing action in the beaver pond that is absent from the other pools.

The reach of Alhambra Creek between Ward and Main streets is unique in its configuration. The original design for this reach called for a narrow, deeper channel to concentrate the flows during low-flow periods with a larger accessible channel to handle flood flows. Instead, a flat surface

paved with turfblock was installed. During low-flow season, this configuration spreads out the water into a thin layer open to the sun. Such conditions also favor factors that result in the unattractive properties described above.

The stream tries to make its own low-flow channel by depositing point bars of sediment at the inside bends. This works to some extent but is limited because too much of this can take away some of the flood protection provided by the project. An adaptive management approach to this situation is practiced: the reach is dredged to ensure that it does not restrict flows more than the passage under Main Street. In this way, some of the point bar deposit is left un-dredged, and this partially simulates a low-flow channel. However, the simulation is only partial and the conditions for unattractive effects still persist.

Alhambra Creek in the beaver dam area is also affected by the tides. Twice a day water flow is reversed by the tide, backing up the water to near Main Street but not to the Ward-Main streets reach. When the tide goes out, the water flows at increased rates back out into the bay. Several days out of the month, when the tides are more extreme, the water is backed up beyond Green Street. These high-high tides overtop the beaver dam at its present controlled height.

This tidal ebb and flow provides a flushing action, which may mitigate some of the conditions that contribute to the undesirable anaerobic (low dissolved oxygen) state of the water, high bacteria populations and to the turbidity associated with high concentrations of suspended organic matter. Tidal flushing may also diminish the growth of floating vegetation. The presence of the beaver dam interferes with "ordinary" daily tidal flushing action, but the "high-high" tides which occur several times a month and reach the Ward-Main Streets reach of the Creek several times a month, still provides some flushing action.

Problem Statement

So, the questions arise:

"Does the presence of the beaver dam exacerbate the anaerobic, fecal bacteria and aesthetic tendencies of Alhambra Creek during the hot, low-flow times of the year above those that would show themselves normally without a beaver dam in place or are they inherent in the nature of the Creek?"

"Does the unique configuration of the Ward-Main streets reach exacerbate the anaerobic, fecal bacteria and aesthetic tendencies of Alhambra Creek during the hot, low-flow times of the year above those that would show themselves normally without a beaver dam in place or are they inherent in the nature of the Creek?"

Option

To answer these questions, the following experimental design is proposed.

Summary: Sample and test the beaver pond, the Ward-Main streets reach, a comparable pond upstream of the beaver influence and another one downstream. Compare the test results to determine if there are any significant differences.

The upstream pool represents the absence of beaver influence. If no significant difference is detected, then the beaver pond is no worse than other pools of Alhambra Creek. If the beaver pond is better, then it is likely that sufficient flushing action is occurring due to the configuration of the pond leveling device and/or the flushing action of the high-high tides. If the beaver pond is worse, then further investigation into the cause will be conducted.

The downstream pool represents a site that still has full tidal flushing action. If no significant difference is detected, then the existing tidal action with the dam at its present height is sufficient. If the beaver pond is better, then it is likely that sufficient flushing action is occurring due to the configuration of the pond leveling device and/or the flushing action of the high-high tides and that some other factor is in play. If the beaver pond is worse, it is likely that there is insufficient flushing and further investigation into the cause is warranted into ways to improve the flushing or the other conditions.

The Ward-Main Streets reach represents a site affected by its unique configuration (wide/flat/no low-flow channel) as well as the presence of the beaver dam. Comparison of this reach with the beaver pond nearer that dam will show if the observed effects are related to the beaver dam or to the channel configuration.

If the findings are otherwise, further testing would be done to determine specific cause, so the situation can be corrected.

1. Find the deepest part of the beaver pond.
2. Select a sampling point in the Ward-Main Streets reach.
3. Find a corresponding pool upstream of the dam's influence.
4. Find a corresponding pool downstream, which is subject to tidal flushing..
5. During low flow and warm times of the year (August or September):

    a. Sample vertical profiles of these deep places, measuring dissolved oxygen, turbidity, temperature, conductivity and pH.
    b. Take spot samples at the sites and analyze for nutrients such as nitrates, ammonia, and phosphates.
    c. Take spot samples at the sites and analyze for fecal bacteria.
    d. Photograph the surfaces of the sites and compare with each other to assess floating vegetation prevalence.

6. Compare results among the sites to determine if significant differences exist.

    a. If the differences are either insignificant or definitive – draw the appropriate conclusions.
    b. If the differences are inconclusive – decide if further work is warranted.

Fiscal Impact

How much will it cost and who will do the work? This work could be a costly or virtually free effort, depending on whether strictly professionals or a mix of professionals and volunteers or a mix of pro-bono professionals or volunteers is used. Cost could vary between $30k and virtually zero dollars. Some laboratories have previously donated analyses and sample containers.

Volunteer have worked with students. Graduate students may want to do this study as part of their work.

Who will pay? Perhaps the City's Clean Water program can pay. How long will it take? Work should start in July and finish by October.

A benefit of doing this work with students and volunteers is the outreach and educational enhancement that can take place.

PERSPECTIVE #2: "NO WATER QUALITY IMPACT"

Beavers have **no real negative impact** on water quality in our Creek.

Under Water Quality, beavers are given credit for improving water quality. See "The Beaver (Castor Canadensis)," Attachment D.

Our Creek is a low gradient creek. From observation, the Creek has a series of small ponds upstream of the beaver dam as well as human created ponds, damming. Concrete weirs are located above the D Street bridge, and other private blocking methods exist throughout the Creek. Vegetation falls and rests in these ponds, making the water appear very much the same as our beaver pond in color. Some ponds are similar in scale to the beaver site, and some are smaller in scale.

What is above the beaver dam is what is below the dam in terms of water flowing through. **In short the water quality is pretty much the same as existing, and more than likely improves the water flowing out of the dam.**

It should be noted that what is behind the dam is running through, and as it did before, runs to the Bay. **The water quality issue is moot, if the water can be safe to go to the Bay it should be safe to slow down and pond above the beaver dam and continue to on to the Bay.**

The water flow pipe is located at a low point of the pond and is draining the lowest water level, the deepest part of the pond. In essence the Creek is running through the pond by pipe and also through and over the dam. All gradients in terms of water elevations are moving and not stagnate.

The tide flow and the beaver dam: At some point the beaver dam blocked the tidal flow beyond the dam upstream. Since the dam lowering and the flow device installation, the tidal flow has returned during many high tides as the tide goes through and over the dam. Now the highest water level above the dam occurs during high tides. It should be noted that the low tides even low high tide seldom make it to the original dam site there is little or not back as mixing does not occur.

The Bay water again causes the fresh Creek water to back up, and the fresh water flows out as the tide recedes.

Water quality testing is not necessary because of the beaver.

Tests may expose other Creek water quality issues or not. What comes to mind is yard runoff containing pesticide and fertilizers.

Water quality testing should be done under for the purpose of finding pollution and hazardous waste and identifying and removing it**, as stated in our General Plan May 1992, "The Alhambra Creek Enhancement Plan." (Attachment E.)**

Beaver Fever, or giardia, is pick up from human contamination. It is stated on page 121 of the "Beaver Natural History of a Wetlands Engineer" that beavers are exposed to giardia from human contamination and are free of such organisms up stream. (Attachment F.)

Attached is a report on "How Do Beaver Affect Local Hydrology on a Watershed in South Alabama" that has **Water Quality references as well.** William W Cross III Department of Earth Sciences, University of South Alabama, Mobile AL. (Attachment G.)

PERSPECTIVE #3

For a variety of reasons, the opinions expressed under this section by one Subcommittee member are not correct or appropriate when compared with the water quality report by another.

CREEK CLEAN-UP

PERSPECTIVE #1

The "Friends of Alhambra Creek" already conduct two Alhambra Creek clean-ups per year. Other partners such as MUSD, EBRP, Shell, and Biota also participate. The beavers are not a direct factor in this effort. Some increase in participation has been noted lately, and this may be due to heightened awareness of the Creek due to "beaver publicity". The beavers have been cutting vegetation in their area of the Creek. If this cutting is considered to be supplemental to pruning that City crews routinely perform, a reduction of workload to perform this task may be considered as a benefit.

Clean-ups are scheduled for:

- April 26, 2008
- September 20, 2008

Fiscal Impact

Direct costs are for the City crew and equipment, supplies, and disposal.

- Crew of four + front-loader/backhoe + dumptruck +pickup truck: approximately $1,000
- Food for Fall cleanup: approximately $200
- Supplies: approximately $100
- Volunteer person-hours: ***priceless***

Expansion of Effort

An expansion of this effort to incorporate pro-active trash cleanup before it gets into the Creek is under discussion among the City, "Friends", the Resource Conservation District and the Alhambra Watershed Council. This may also include and outreach and educational effort. This was an indirect result of heightened awareness of the Creek and the debris it carries from the increased surveillance of the Creek in connection with the beavers. It is too early to estimate costs. If it is done, the effort and cost will likely be shared. In the long run it is much cheaper to pick up trash before it gets into the Creek.

A working prototype should be developed this year.

PERSPECTIVE #2: "BEAVERS CLEAN THE CREEK"

Creek clean-up is an area where cost of the beaver can be deferred in terms the Creek cleaning. The beaver credit for clean-up can be characterized as off-setting the cost of the maintenance costs attributed to the beaver.

The beaver have cleaned the Creek from the dam to above Ward Street and deposited trees (65 counted) and debris at the dam site, where City staff loaded it in trucks during dam removal. A rough figure of at least equal of the January staff cost of $15,000. It would be reasonable to add credit to the beavers for removal of other vegetation they need for feeding on reeds and grass. Dredging of mud was also observed and has a flow improving credit. Let's say another $10,000 for both. This is probably conservative, but it is a start.

The beaver activity has improved water flow, and they have manicured the Creek in a way very pleasing to the eye.

PERSPECTIVE #3

The opinions and figures stated in Perspective #2 are not based on any independent objective analysis or findings. Instead, they are purely subjective and more unsubstantiated advocacy for retaining the beavers in Alhambra Creek.

CREEK WALK

PERSPECTIVE #1: "CREEK WALK IS CITY POLICY"

Expand on the Integrated Greenway concept outlined in the 1992 Alhambra Creek Enhancement Plan. Expand it to include the entire creek stretching along the creek to Nancy Boyd Park and the balance of the creek in Martinez. Charter 15 of the Downtown should also be used and expanded on to complete the Creek Walk encompassing the entire creek as mention above. Chapter 14 should also be implemented in terms of signage for the creek walk.

Immediate steps should be taken to define the entire Creek Walk. The Creek Walk can be implemented by defining the route with simple trails, gravel, and markings, Signs, on proposed trials and street type trails, side walks. Some of the markings can be painted on the sidewalks, in animal themes. Animal themes can also be used on signs, different animals themes for different parts of the creek showing their living area. Bike routes adjacent to the creek as outlined in the Alhambra Creek Enhancement Plan should be included.

All existing bridges should be incorporated in the Creek Walk as they function as overlooks to the creek.

See "Alhambra Creek Enhancement Plan," Attachment H. See Chapter 15 and 14 of the "Downtown Specific Plan," Attachment I.

PERSPECTIVE #2

There currently exists a Creek Walk of sorts. The question of whether it should be expanded or improved is a valid one. Historically, Alhambra Creek has been synonymous with flooding and a convenient, although unlawful, place to dump unwanted personal property and yard waste. There have been positive things over time, both by citizens' groups and the City government. The downtown beautification and flood control project was completed in 2000-2001. This project enhanced the charm of downtown, improved the flood control capacity of the Creek thus reducing flooding, and provided greater visibility to the Creek marshland.

Notwithstanding these improvements, there is more that could be done. The City should consider integrating the Creek more into the town and its people. Martinez could become a destination if business and housing were tastefully incorporated into the Creek area and a Creek Walk. The City could even consider incorporating electric powered and reduced sealed versions of the Italian/Portuguese fishing boats that people could ride along the stretch of Creek from the mouth of the bay to downtown.

BANK STABILIZATION/ Burrowing

PERSPECTIVE #1

Issue Definition/Problem Statement

Groundwater: During the course of a rain storm, some rain water will infiltrate into the ground. This infiltrated water will travel through the soil and become part of the ground water system. Ground water ultimately drains through the soil to the lowest point in the watershed. Depending on the geology, some water may be captured in a perched location or migrate deep down into an aquifer hundreds of feet below the surface. For the purposes of this report, however, we will focus on the ground water and soils adjacent to the creek.

Ground water that migrates to the lowest point in the watershed will ultimately drain into

the creek, which provides summer flows that sustain the Creek's habitat. If the water level in the creek is elevated then ground water can be "backed up" into the soil surrounding the portion of the Creek with the elevated water surface. This could result in saturation of soils that would previously drain and may in turn affect the bearing capacity of the soil for structural foundation members.

Burrowing: Burrowing by animals residing in the Creek, such as beavers and muskrats, can create tunnels in the Creek bank. If burrowing is extensive, there may be concern that it could impact the stability of the Creek bank and/or property immediately adjacent to the Creek.

Objectives/Assumptions

Groundwater: The objective is to determine if the presence of a beaver dam will impact the soil properties adjacent to the creek due to the pond behind the dam. The other concern with increased ground water levels would be impacts on buildings with basements and the potential for elevated ground water draining into basement areas. If impacts are identified with elevated ground water, then options to mitigate these impacts would be developed and implementation and maintenance costs identified.

The study prepared by Phillip Williams Associates (PWA) dated October 16, 2007, indicated the beaver dam was six feet in height. In early January 2008, the City and Skip Lisle constructed a pond leveling device and lowered the dam below six feet. The installed pond leveling device insures a stable dam height. The current dam height should be measured to determine the increased height of the pond over the historic water elevation in the creek to accurately assess any potential impacts.

Burrowing: The objective is to determine if beavers or the habitat created by the beaver dam result in burrows dug into the creek bank. It is assumed that there is some burrowing into the creek banks as determined by visual reports. The task is to determine if these burrows are superficial and not a concern or if they are or will become extensive and deep burrowing that could be cause for concern.

Options

Groundwater: Before options can be developed, a Geotechnical Consultant would have to analyze the soils surrounding the beaver dam (soil permeability, soil type, etc.) and any impact an elevated section of creek water would have on the surrounding groundwater elevation and the extent the influence would reach beyond the centerline of the Creek. It is unknown whether a six foot high dam and pond would create an impact on the groundwater and surrounding soils. It may be possible that a smaller dam may have no impact on the groundwater. Until a report is developed, no future analysis can be performed.

Burrowing: If burrowing is a problem, the Creek bank can be protected to discourage or deter animals from burrowing. Lining the Creek bank with rip rap or fencing mesh will eliminate burrowing.

PERSPECTIVE #2

The beaver lodge is the center of a beaver colony.[1] While the well known "island lodge" is best recognized, the lesser known "bank lodge" is equally as common.[2] The Martinez beavers have

built a bank lodge, and like all lodges, it has several exits for safety. When the water level was lowered, these openings were exposed, although they have since made new exits/entrances below the waterline. The beavers regularly scoop mud from the bottom of the creek and place atop the lodge to secure the roof area.

Beavers begin lodges by first using "Bank holes" which are tunnels in steep slopes with the entrances under water.[3] These can be developed later into lodges or used as an alternative to the lodge when the female and new kits are taking up more space. Beavers are powerful diggers and are able to burrow through mud and clay.

Recently, City staff measured an upward sloping hole which they described as "10 inches in diameter and 11 feet deep into the bank". There has been considerable concern by property owners that such burrowing behavior could weaken banks and negatively impact structures. A subsequent geotechnical report was obtained by the property owners which stated[4]:

> Severe erosion, tree falls and bank stability problems are now occurring and have reached critical levels near the lodge and dam areas, locally undermining adjacent walls and structures. These problems are expected to get even more severe in the future during continued dam building and re-building efforts after major storm events, when further loss of vegetation and removal of mud from within the burrows is needed as part of the dam re-building process.

This report concluded that damage caused was considerable and would increase with subsequent erosion to the bank and continued semi-permanent water levels.

Significant errors in this report include the fact that beaver-tree removal allows roots to remain and does not, therefore, lower bank stability. In fact, as trees struggle to maintain root to shoot ratios over time, the effect of this coppicing will be to increase bushy growth.[5] In addition, it is not clear that these holes were made by beavers, as the Martinez beaver adults are significantly rounder than 10 inches in diameter. Muskrats are also pernicious diggers and frequently begin tunnels at dam sites to make nests or burrows

The damage caused by muskrats, primarily by burrowing in containment and separation berms, is not a matter of conjecture. There are several examples of compromised parallel cells, in which divider berms have been breached by burrows (Estevan, SAS (Duncan et al., 1999); Corcoran, CA (Gao et al., 2003); Sacramento, CA (Nolte and Associates, 1998)). At the Manitoba Interlake Site 1, muskrat burrows were extensive and threatening to breach the dikes at several locations, causing the owners to rebuild the dike and install muskrat deterrent fencing. Roads have been damaged by burrow collapse at Saginaw, MI (unpublished), and at Sacramento. While there has been no recorded instance of catastrophic containment levee failure, increased leakage has potentially occurred at some sites.[6]

Muskrats are well known for their tunneling and are often considered a threat to man-made dams because of their habit of burrowing along their base[7]. While they live in push-up houses of reeds in marsh areas, they are known to burrow along creeks and steep banks. Muskrats live in burrows in areas where lake and river margins have steep banks formed of easily dug soft sediments.[8] Population density of muskrats is greater per acre than for beaver, and their impact on the habitat can be correspondingly more significant.

Perhaps the most troublesome muskrat activity is their digging and burrowing…Some chose the periphery of the marsh and actively excavate bank burrows for protection. In lakes, ponds, creeks and rivers, bank burrowing is a normal activity…Fluctuating water levels aggravate the problem by forcing the animals to continually dig to keep their living quarters above the water level. Vehicles or livestock can cause the burrows to collapse further damaging the dike or dam"[9]

Obviously, both muskrats and beavers have been known to cause difficulties with bank digging. Differentiating between the two is actually a complex task even for wildlife experts.[10] Simply removing beavers from the area may not control the bank erosion problem, as muskrats may continue to tunnel, and may even begin digging from the current beaver lodge once it is vacated. The better solution is to address the issue of bank permeability, so that neither species is allowed to weaken the bank.

A recent article published in Ecological Engineering titled "Muskrats: In treatment Wetlands", examines problems caused by the creatures and possible solutions. It carefully explores the cost and efficacy of each intervention, and this article is available for online review at http://www.kerrn.org/pdf/kadlecetal2007.pdf. Both this article and the geotechnical evaluation name riprap as a possible solution, although this may not be aesthetically acceptable given that this section of the creek was purposely maintained with a natural appearance. Another possibility with considerable success is wire mesh or chain link fencing used in what the article calls "Berm Slopes Surface Protection". This extends above and below the waterline and must be securely anchored with rebar. Either of these techniques would prevent both beaver and muskrat tunneling. However, the chain/mesh technique can also be planted with vegetation to increase stability and augment attractiveness.

PERSPECTIVE #3

It is not clear if there are bank stabilization issues due in whole to beaver activity. The burrowing of beaver is quarrying for mud and bank hole for protections these are usually shallow and parallel to the bank. **Stabilization of banks can be many kinds of causes: Non compacted fill, rotting tree roots, other animal sources, abandon pipes and other debris, and can be easily remedied by concrete injection or other simple means, by the responsible party e.g. city or property owners or combination. See attached** MUSKRAT AND BEAVER MANAGEMENT IN WETLANDS: PLANNING AHEAD FOR WILDLIFE SURVIVAL (Attachment J.)

Concern issue raise by an engineer is presented less the objective terms. Information has been given to an engineer that beaver activity is a potential cause for water in the creek causing damage to buildings. The descriptions of the activity is exaggerated, non proven and stated to have occurred in parts on the creek that it has not and in some cases not relatively close the property of concern.

The majority of the buildings in this area are protected by substantial bank stabilization and erosion control, major steel and concrete walls, and a concrete box culvert, typically having a concrete bottom, some of which could be affecting the properties down stream in terms of erosion.

Removal of vegetation by beavers can be characterized as a benefit to flood concerns rather than a threat to bank stabilization especially when beaver cut willow trees above the root line and sprouting occurs in spring. The root structure remains and if fact the tree is less apt to be washed from the bank in heavy flows. All vegetation is not removed as characterized by engineer. Trees were also cut by property owners in the city.

Of particular interest is the concern the lodge which is built the east bank which looks to be a former silt deposit placed against a sheet pile and concrete retaining wall going to the bottom of the creek, thus protecting the bank, which is on the other side of the retaining structure, from beaver activity. The eddy that is also mention is this area is a preexisting flow condition.

The engineer armed with partial information has ignored the fact that all these condition were preexisting to the beaver going back to the time before the building were placed in the flood plain and have to continue to occur as a result of increased flow due development upstream increasing scouring in the creek. In fact even scouring of banks is less when there is a beaver pond.

IMPACTS ON OTHER SPECIES & ENVIRONMENT

PERSPECTIVE #1: SUMMARY

Beavers have a huge impact on the creek they inhabit. They affect the vegetation, insect and animal life by creating deeper slower water and improved ecological conditions. While beaver ponds can raise water temperature in ways that may negatively impact trout, research has consistently shown that they increase steelhead and salmon. Both species have been shown to successfully navigate dams. If the Martinez beavers remain, research tells us that we can expect more varied fish, amphibian and birdlife to make use of the pond. Although a pre-beaver species list was never compiled for this section of Alhambra Creek, the area has been documented through extensive video and photographs for the past year and a half. Thus differences in the variety and density of other species noted can be clearly observed by looking at prior footage.

What happens to the neighborhood when beavers move in? Surely their visible impact on vegetation and waterways disrupt riparian habitat? The best answer is the more complex: beavers can have both a restorative *and* damaging effect on different aspects of their habitat under different conditions. Although instinct and common sense might suggest the Martinez beavers are depleting their Creek environment, there is a large body of scientific research that says the benefits of beavers significantly outweigh the costs in most areas[11]. While study after study has shown that beavers *do* impact their habitat, the impact is largely for the better. In this section of the report, the impact of beavers on specific aspects of their habitat will be examined.

Keystone Species

The beaver is often called a "Keystone Species". This concept was introduced in 1966 by R.T. Paine who studied the impact of removing one predator from an ecosystem.[12] (In that case a

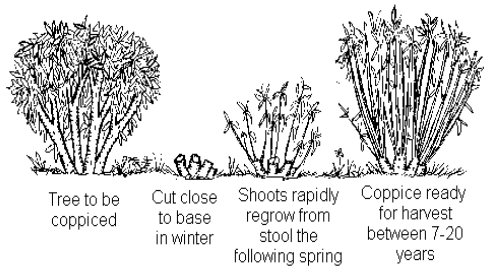
starfish.) He found that the original 15 species community was quickly reduced to only 8 species when the starfish was removed, prompting his analogy to the collapse of an archway if a "keystone" is taken out. (The keystone is the center piece which holds up both sides of the arch.) Beavers have a similar role because their dams create habitat which are used by other wildlife. Bruce Baker, Ph.D. & Edward P. Hill wrote the seminal chapter on beavers in Feldman's Wildlife of North America (2003). They described the beaver's role as both a keystone species and an ecosystem engineer.[13]

Beavers change soil deposition and augment nutrients in pools. There is even a growing body of evidence that dams may act as a kind of filter that improves water quality.[14]

> A keystone species is one that greatly influences the species composition and physical appearance of ecosystems (Paine 1969) and whose effects on ecosystem structure and function are both large overall and disproportionately large relative to its abundance (Power et al. 1996). An ecosystem engineer is a species that directly or indirectly controls resource availability by causing "physical state changes in biotic or abiotic materials" (Jones et al. 1997:1946). The beaver is a definitive example of both a keystone species and an ecosystem engineer.

Beaver Impact on Vegetation

Beaver foraging affects vegetation growth patterns. They remove trees and branches for food and dam-building. By current estimates, some 60 trees of various sizes have been taken by the Martinez beavers, almost all native Arroyo Willow. However, the roots remain in tact and will retain bank soil and eventually create new growth. Beavers use natural "coppice" cutting of trees[15], a forestry term for spurring future brushy growth by removing the main trunk and allowing shoots to spring around the base.



"Beavers coppice willow and cottonwood trees, creating the low, dense habitat preferred by vireos[16]. Indeed, beaver foraging promotes the growth of willow[17]"

A not-uncommon sight over the summer was to see a large partially felled tree sticking out of the stream. This is a kind of "beaver refrigerator"---the beaver does this to allow foliage to continue to grow and stay "fresh" but to make feeding more accessible for the kits. Beavers have been shown in some studies to decrease tree density, and their selective foraging can reduce some species and increase others.[18] They shape tree dispersal by removing target food trees and leaving others to grow and reproduce.

> ing season (Kindschy 1985). Where stem cutting is concentrated in late fall to build dams or prepare a food cache, plants are dormant when cut and respond with new shoots in the next spring in an attempt to recover former root:shoot ratios, maximizing plant production and minimizing plant damage. Cutting by beaver can also stimulate plants to initiate growth earlier in the spring, further increasing stem production (Kindschy 1989). However, biomass of new shoots can be decreased if regrowth is browsed by native ungulates or livestock.

One key factor as to whether or not vegetation is depleted or enhanced is the browsing of livestock[19], which can produce enormous impact especially during dormant months when grass is less desirable. Obviously this is not an issue for this beaver habitat. Nonetheless, considerable interest has been expressed in augmenting willow habitat for the Martinez beavers with replantation, and this is discussed under the volunteer section of this report.

Beaver Impact on Insects and Other Invertebrates

Dams slow current and increase deposition of sediment and organic material in the water. These ponds play a key role in the development of complex insect life, which in turn feed fish, birds and mammals. Beaver activity greatly affects both aquatic and non-aquatic insect life in response to increased sediment deposition and still water behind the dam. Insects that prefer running water are replaced by insects that prefer still water, and the variety and density of species has been shown to increase[20].

> In a study that compared stream riffle sites above and below beaver dams in the Adirondack Mountains, sites immediately below dams had lower invertebrate richness and diversity, but higher total invertebrate, predator, and collector–gatherer densities (M. E. Smith et al. 1991).

This, of course, leads to natural questions about mosquito larvae which are known to accumulate in still pools. However, beaver ponds have been shown to actually reduce mosquito population[21]. There are nearly 3,000 known species of mosquito, but beaver ponds tend to shift composition of larvae – making conditions less desirable for some and ideal for others.[22] All mosquitoes are not created equal; some are much more damaging to human populations. For example, one of the species most associated with West Nile Virus and yellow-fever (*Aedes)* cannot survive in the permanent water of a beaver pond.[23] Continued involvement by Mosquito Abatement can monitor conditions and help control negative species.

Beaver Impact on Fish

Grant county Conservationists

Beaver ponds impact fish in many ways. It has been shown that the standing crop of "plankton" in beaver ponds is 5 times larger than in the unaltered flowing stream[24]. This means that fish life is denser and more varied. In fact, this winter's Oregon TWS Conference on Beavers featured a lecture on the promotion of beaver to *increase* salmon.[25] Kelly Moore, NW Region Program Manager for ODFW research lab wrote, "The primary effect is on over winter survival of juvenile salmonids – streams with abundant beaver created habitat had 2-3 times better over winter survival rates than streams with simpler riffle-pool structure." [26]

There has been concern that ponds impact reproduction by raising the temperature of the water and obstructing flow and dispersal of fish. The Oregon Department of Fish and Wildlife has noted that beaver dams can interfere with salmon passage. However Ms. Moore continues, "The consensus of Oregon fish biologists is that the benefits clearly outweigh the negative effects and that salmon and trout are better at moving over, around, and through beaver dams than we thought." She referred to a much-referenced native legend called "Beaver taught salmon how to jump" which basically credits beaver for salmon prominence[27]. Recent research shows that salmon and steelhead can navigate dams in periods of high flow and that the dam itself becomes a kind of reproductive "source" in fish community and dispersal. Even small ponds have been shown to impact the diversity and density of fish species[28].

> ponds. The size of beaver ponds is also important. As expected from general species–area relationships, fish species richness increases with size of pond, but very small beaver ponds can have higher than expected richness compared to ponds of a similar size not impounded by beaver (Keast and Fox 1990). Thus, beaver have a strong effect on fish species richness, but the effect is dependent on the size and age of beaver ponds and how ponds are distributed within the landscape.

Beaver Impact on Amphibians and Reptiles

Beaver ponds create an ideal habitat for amphibians. Some species of newt may actually depend on beaver ponds for their survival[29]. Frogs, salamanders, and toads are the hallmark of a healthy beaver pond. Towards the end of summer last year, limited frog song could be heard at our beaver pond which had not been documented before. Now a strong chorus of many pacific tree frogs can be heard at dawn. *"Amphibians, as a group, are sensitive to changes in water quality and so are considered indicators of environmental cleanliness."*[30] The return of these frogs reflects the habitat restoration done by the beavers[31] and its subsequent benefits. There is some evidence that certain species are increased by the presence of beaver ponds (such as frogs) while others are decreased (such as salamanders).[32] Turtles and other reptiles seem to gravitate towards and rest above the lodge, which is often warmer than the surrounding terrain.[33] There has been research documenting that older beaver ponds produce more kinds of snakes, lizards and turtles than younger beaver ponds, but that even a young pond had more reptile species than an undammed stream.[34]

Beaver Impact on Birds

A morning stop by the beaver pond reveals a larger cast of avian characters this winter than last. An early response to the deeper water was a breeding pair of secretive green heron that used the brushy shores to hunt for an increased fish population. By mid-summer kingfishers and great and snowy egrets were observed on both sides of the dam. A cormorant paid close attention to the dam lowering efforts by city staff in December and was photographed feeding opportunely on the fish suddenly displaced. The experience was so appreciated he continues to frequent the area, joined by a collection of winter ducks, coot and grebe. Observed songbirds include the marsh wren, song sparrow and common yellow throat. This spring, many barn swallow families produced a second clutch of young, and at least 2 black phoebes were fledged. Winter visitors have included a ruby-crowned kinglet and a regular flock of nearly 30 lesser scaup that arrived unexpectedly in early February, possibly to feed on the sudden chorus of tree frogs but definitely

enjoying the bubbling mussels in the mud seen as far up as Starbuck's. Certainly not every visitor is seen everyday, but at least one makes an appearance on any given day. This is not unexpected given the research on beaver impact on bird life.

> "A survey of birds at eight beaver ponds in eight counties in New York State demonstrated that active beaver sites support more species of birds than do vacant or potential sites."[35]

Beavers create better foliage and feeding for birdlife, allowing a greater variety and density of bird species to accumulate. Although beaver is occasionally cited as destroying habitat for songbird nesting[36] their gnawing actually spurs the very type of growth most breeding birds prefer. This summer, Audubon Magazine reported on the beneficial effect of the "Bronx Zoo Beaver" on the surrounding population of birds and fish, saying, [37]

urban action. "Here is nature doing what we couldn't even imagine," says Eric Sanderson, an ecologist with the Wildlife Conservation Society, which oversees the Bronx Zoo. The rebounding Bronx River is now home to 45 species of fish and serves as a migratory corridor for birds. José

Often when waiting for the arrival of the somewhat unpredictable beaver, visitors can pass the time by watching the more visible and varied birdlife.

Beaver impact on Other Mammals

Mammals are most likely to be seen where they can find food, water and cover. Obviously the deeper pool, denser foliage created by coppice cutting and augmented fish and insect life draw other mammals to the beaver pond[38].

> ponds. Beaver ponds also create habitat for other semiaquatic mammals, such as river otter, mink, and muskrat, some of which may occur in a large percentage of active or abandoned ponds. In Idaho, the density and standing crop biomass of small-mammal populations was two to three times higher in willow-dominated beaver pond habitat than in adjacent riparian habitat (Medin and Clary 1991). Montane voles (*M. montanus*)

Our small stretch of beaver pond has already revealed at least two families of muskrats, an adult otter and baby otter this summer, a succession of raccoons and other small rodents. Obviously the most exciting of these is the otter, which feed on the fish that the beaver dam encourages. Interestingly, beavers and otters tend to overlap in their habitat a great deal. (It was not uncommon to see the baby otter going over and even *inside* the lodge at times!) However, they are not exactly friends and the few aggressive tail slaps seen by these beavers haven often been in response to otter. Otters are carnivores and there is some research to indicate that they can take small kits at times. Indeed, many sources consider them a natural predator of the beaver.

Perspective #1: Conclusions

The Martinez beavers have a huge impact on the Creek they inhabit. They affect the vegetation, insect and animal life by creating deeper slower water and different ecological conditions. Obviously potential impact increases with the age of the pond and the size of the family. If the beavers remain, research tells us that we can expect more varied fish, amphibian and birdlife to make use of the pond. Although their effects can be both positive and negative in nature, most naturalists agree that the general influence of beavers is a beneficial one.

PERSPECTIVE #2

A member of the Subcommittee would like to include the http://www.beaverdam.info/ site attached; it covers many of the benefits. (Attachment K.) Also included is The Beaver Natural History of a Wetlands Engineer, page 110**, "Mosquitoes become less numerous in beaver ponds, and the species composition of the populations change." (**Attachment L.)

Also attached is Otto and Johnson's Beaver Influence of Fisheries Habitat, copyright 2000-2005, pages 1-26. Please **see pages 11-13 about benefits to steelhead and also willows,** but the whole report is valuable. (Attachment M.)

As a cost-benefit the improved habitat for other species should be given a dollar value. We have spent resources in the past to create habitat**. A rough estimate of the benefits of the beaver in terns of creating habitat would be in the tens to hundreds of thousands of dollars range**.

Benefits to humans are many a sense of peace, soulfulness, social development and many benefits to child development. See Educational Aspects.

PERSPECTIVE #3

There is no independent objective information presented to the Subcommittee which would support the opinion that the beavers in Alhambra Creek are a keystone species. Moreover, at the end of the third paragraph of Perspective #2, my comment is: This is not supported by any information presented to the sub-committee.

The opinions and conclusions regarding the change in species in Alhambra Creek after the arrival of the beavers is a subject which has not been independently established or verified. The mere claim that a certain species has increased or the return of other species following the arrival of the beavers is a bootstrap opinion and conclusion.

Alhambra Creek, its watershed and flood control dynamics are unique and may not necessarily be comparable to other waterways that beavers inhabit. Therefore, it would not be prudent to rely on the information, opinions and conclusions expressed in this section for purposes of making a decision regarding whether the City should adopt a Beaver Management Plan to retain beavers in Alhambra Creek.

POPULATION, CONTROL, DISPERSAL

PERSPECTIVE #1: SUMMARY

Unlike other rodents, beaver populations grow slowly. They breed only once per year and do not reach sexual maturity until age two. Kits remain with their parents for two years, and then disperse to seek habitats of their own. A survival rate of 50% is not uncommon, with dispersal being the most dangerous time in a beaver's life. Population can be successfully managed through many techniques including relocation and immunocontraception.

Population Growth

The issue of population growth potential has been a concern for many. Beavers are rodents, and this classification implies a rapid population increase with swift reproductive readiness. However, in this arena beavers are uniquely un-rodent-like. Adults are monogamous and produce young only once per year[39]. Kits are not sexually mature until age two and remain with their parents until 23 months of age[40]. Although botanist Mary Tappel was quoted in the Martinez News Gazette saying that beavers breed for 50 years, research confirms they very rarely live past age 15, reach their peak re-productivity rates at age seven, and generally discontinue bearing young after age twelve[41,42,43].

Territorial Nature

Beavers are highly territorial and have an estimated home range of about two miles. They use scent mounds to declare their territory and discourage interlopers. This means that you will never get more than one family within an area (presumably a mile above and below the current lodge). A beaver colony typically consists of two adults, 2 yearlings, and 2 kits. Colonies of more than 8 are very rarely reported. Yearlings stay with the colony to help raise the new kits and learn more about beaver responsibilities. They typically disperse before their second birthday, when another set of yearlings is present and a new delivery of kits, expected. In general, the term "dispersal" (rather than migration) is used to describe when kits leave the colony to begin their adult lives. This period of dispersal is the most dangerous of a beaver's life as they have no safe pond or lodge to hide in and no guaranteed food source.

Breeding

Adult beavers breed in January, and females gestate for around 110 days. Our adults were filmed breeding at the end of December, and it is likely the female is currently pregnant. Kits are born in mid April-May depending on elevation. Young are born fully furred and toothed with their eyes open. They are considered a *precocial* animal, meaning that they are never helpless or confined to their parents nest. Within hours after their birth they can explore their habitat and even swim. Initially their fur is not water repellant and they require grooming by a parent or older sibling to survive the cool water. By two months they can dive, swim, stay underwater and walk upright. A mortality rate of 40% is not uncommon in the first year, although the beavers' greatest danger occurs when they disperse from the family lodge.

Dispersal/Migration

Given our current reproductive survival rate of 50% and the likely dispersal survival rate of 50%, population will be a minimal concern. Our current two kits will not relocate until March of 2009, and then must travel at least 2 miles from the family lodge to settle. Females reportedly go farther than males in this effort, often as far as 20 miles[44]. While there is a slight tendency for dispersers to prefer downstream rather than upstream, they are equally likely to go either direction. During this dangerous and exciting period of relocation, most beavers find their mate from another colony. With 2009 a long ways away, now would be a good time for the city to examine the Creek and consider where might be a more desirable place for a disperser to settle. The designated area could be made more attractive with the planting of willow, provided that it has the necessary attributes for beaver settlement. If the City wishes to prevent any upstream migration of young, they will need to work on a beaver-discouraging obstruction. Such a fence was suggested by expert Skip Lisle when he was installing the leveler, and he has indicated that he would happily consult with the city further.

Downstream dispersers are likely to go into the Carquinez Straight and continue until a suitable inlet is found. Should population growth become problematic, techniques for population management may be employed. The most obvious is live trapping and relocation for yearlings. With the right care and management this could be a feasible (although expensive) solution. (See section on beaver relocation.) Adults can also be live trapped and sterilized, although this is traumatic and invasive to the animal. Mary Tappel reportedly advised staff that an adult could be removed so that the remaining parent would then breed with a kit. While this is theoretically possible, such inbreeding would be genetically damaging and counter-productive in the long run. Obviously if beaver incest was common in the population, their species recovery rates would be much more sporadic and unhealthy. Moreover, while adult-kit breeding has been documented, it is more likely that the remaining adult would simply encourage another adult beaver to settle with the colony, and this would render a labor intensive and unpopular action effectively meaningless.

Population Control

The preferred population control method recommended by the Humane Society of the United States is "Immunocontraception"[45]. This refers to a contraceptive technique that uses the body's own immune system to prevent pregnancy. The Humane Society recommends the use of PZP (*porcine zona pellucida*) as an Investigational New Animal Drug (INAD) to control pregnancy in populations of wildlife where it is appropriate. The Tule Elk at Point Reyes National Seashore receive yearly treatments[46]. PZE is administered through an injection, which can be hand delivered or given through dart/blow gun or CO_2 pistol. A once-a-year administration is sufficient, with the effectiveness lasting only for that year. Treatment does not affect current pregnancies.

PZP is experimental and only allowed in the context of current research. However, the Humane Society and the Sierra Club have both expressed interest in the Martinez Beavers and a willingness to offer help, guidance or consultation if needed. Both of these large organizations have biologists who could easily connect us to a treating program. In addition, this population has sparked enough academic interest on its own to justify a research trial if such actions are warranted.

In conclusion, beaver populations grow slowly and can be managed through many techniques including relocation and immunocontraception. If Martinez makes a commitment to keeping these beavers, dealing with the limited progeny will be an entirely surmountable hurdle.

PERSPECTIVE #2

Beaver are not a "boom and bust" species. Their population change slowly and is controlled by available habitat. We have a small group and there is a high mortality rate among young beaver. Chances are that we might lose another juvenile before spring. There will be plenty of opportunity to study this issue if it occurs. Our beavers should remain natural as a study group. Interference should be avoided.

Note: sterilizing wildlife or animal birth control is not a management tool at a City's disposal; there is not indication it is appropriate with the species or even need.

It is important to embrace the ideal of these particular beavers, in this particular Creek, at this particular time. Rather than act on the impulse to address a non-existing issue. Beaver tend to be site specific, and we have a very unusual site. Beaver are dynamic in this regard.

Skip Lisle has said as much several times, that we will see and there is not real way of predicting.

See the "Beaver Natural History of a Wetlands Engineer," pages 88-91. (Attachment N.)

PERSPECTIVE #3

The opinions in Perspective #2 are generalizations and ignore the fact that the beaver population could spread. There is nothing offered in terms of how the beaver population would be controlled or limited from its initial numbers, if the City chose to maintain beavers in Alhambra Creek. This is a slippery slope that once embarked upon could well become problematic in the future.

EDUCATIONAL OPPORTUNITIES

PERSPECTIVE #1: SUMMARY

The "public and visible" character of the Martinez beaver colony presents numerous educational and outreach opportunities, some of which are already being exploited. The Martinez City General Plan makes provisions for using the creek as an educational amenity. Other educational opportunities are discussed elsewhere in this report.

General Plan Support

The Alhambra Creek Enhancement Plan, adopted as an amendment to the Martinez City General Plan by Resolution No. 160-92 contains Goal 6: ***"Create public, creek related educational options throughout the greenway corridor"***

Opportunities

The way beavers live: in mutually supportive family units with a cooperative social structure makes them especially suitable subjects for study by children. They model many of the desirable attribute we would like our children to learn. **The benefit of this is priceless.** To create an equivalent site from scratch would cost hundreds of thousands of dollars. Much of this resource is already in place for a fraction of the cost. Some additional enhancements would further enrich the experience

1. General Public – visitors to site

The public benefits from observation as in going to a museum, interpretive center, or zoo or nature park. The Martinez General Plan through the Alhambra Creek Enhancement Amendment states: "***Where appropriate, and consistent with wildlife habitat goals, create overlooks at the banktop with educational exhibits explaining the history and ecology of the creek."***

a. Interpretive Signs
   i. Cost: $500 per sign, say $2k for four.
   ii. Cost share City with community groups.
   iii. If designed by students with aid of graphics professionals (pro bono) would reduce cost and increase educational value.
   iv. 6 months

b. Brochures
   i. Cost: $100 to $1,000, depending on the colors, type of paper, design costs, etc
   ii. Cost share City with Chamber of Commerce, Main Street Martinez, and Community Groups
   iii. If designed by students with aid of graphics professionals (pro bono) would reduce cost & increase educational value.
   iv. 2 months

c. Web Page
   i. If owner is willing, it could be adopted by the community with a team to gather information, edit & install.
   ii. Cost: mostly in-kind effort, not much cash.
   iii. Already exists

d. "Beaver Cam"
   i. Cost: $1 to 2k.

ii. Cost share City with Chamber of Commerce, Main Street Martinez, and Community Groups
iii. Ongoing cost of maintenance etc.
iv. 6 months

e. Guided Tours with docents
i. Cost: mostly in kind – use volunteers, say $2k to develop materials and docent presentation content and training.
ii. Docents generated by Main Street Martinez, Martinez Historical society, Friends of Alhambra Creek, MUSD, Martinez Parks and Recreation.
iii. 2 months

The Alhambra Creek Enhancement Plan states: "***Along the creek, as it moves from freshwater stream to brackish and saltwater marsh, alternative locations for educational exhibits are suggested at special stations or overlooks***." The benefit to students in terms of social development and learning is also priceless:

An emerging body of evidence indicates that contact with nature is an important part of healthy childhood development.

"Nature-deficit disorder is not an official diagnosis but a way of viewing the problem, and describes the human costs of alienation from nature, among them: diminished use of the senses, attention difficulties, and higher rates of physical and emotional illnesses. The disorder can be detected in individuals, families, and communities."
— Richard Louv, Last Child in the Woods

A compilation of recent information on the beneficial effects of direct contact with nature is provided in the appendix to this report. The beaver colony can be a significant asset for nurturing "Nature – Smart Kids" in Martinez.

2. <u>Targeted to K-12 Students</u>
   a. *Field trips – see "docents" above*
   b. *Develop classroom curricula using the beavers as a theme* – Can include the sciences and nature study, but also social studies, such as civics to understand process of how "the City/Community learned or did not learn to live with the beavers," art, English composition, poetry, and history.
   c. Classes can work in shifts to "adopt the beavers"
   d. Environmentally themed education is already being successfully applied to at the Martinez Unified School District's Environmental Studies Academy to revitalize at-risk students. This program uses Alhambra Creek as a significant educational amenity. The beaver colony can be a significant enhancement to this program.

3. <u>Used by college and post-grad students for class projects/theses subjects</u>.

With these urban beavers, Martinez is at the cutting edge of the movement to co-exist with wildlife. Higher education research on wildlife and how it returns after habitat restoration is a rich area for investigation**.** The study areas are numerous, hydrology, wildlife management,

social benefits, nature in cityscapes etc. **The benefits are beyond the money already spent. The framework is in place just add research.**

a. Martinez beavers are uniquely visible, accessible and people-tolerant. This enhances opportunities for study of the beavers, their behavior, as well as human behavior.
b. Direct cost to the community would be minimal. Indirect costs would be whatever it costs to coexist with the beavers.

PERSPECTIVE #2

The beaver site benefits education as follows:

Education covers three major categories, General Public, visitors: The public benefits from observation as in going to a museum, interpretive center, or zoo or nature park. **The cost benefit of this is priceless, if a number has to be put on creating this it would in the hundred of thousands of dollars. We have this resource in place already for a fraction of that cost.**

Second is K-12 education: We have this resource in our city for use in add grades. Lesson plans can be created to benefit students in our schools and well as schools out of the area**. This outside nature classroom idea is outlined in our city's General Plan through the Alhambra Creek Enhancement Amendment.** The **cost benefit again is priceless** the number would be again in the hundred of thousands of dollars**. Again we have this in place for a fraction of the cost.** Curriculum can be made and even sold. The benefit to students in terms of social development and learning is also priceless and is stated in the following attachments.

Lastly is higher education research on wildlife and how it returns after habitat restoration**. We are at cutting edge of the movement of co-existing with wildlife in this unique setting**. The study areas are numerous, hydrology, wildlife management, social benefits, nature in cityscapes etc. **Again the benefits are beyond the money already spent. And the frame work is in place; just add research.**

Please see hard copy attachments and electronic ones as well:
http://www.cnaturenet.org/research/volumes/C16/16 Title Children & Nature Network - March 24, 2008. (Attachment O.)

http://heapro.oxfordjournals.org/cgi/content/full/18/3/173 Title: Health Promotion International, Vol. 18, No. 3, 173-175, September 2003
© Oxford University Press 2003 (Attachment P.)

VOLUNTEER ENGAGEMENT

PERSPECTIVE #1: SUMMARY

A successful management plan will include volunteer efforts to maintain habitat, reduce human interference, coordinate public interest, and facilitate appreciation of the animals. Already many interested beaver-supporters have pledged their time, energy and creativity for these purposes. Although there are some tasks for which the City will clearly prefer to maintain control (such as dam maintenance), it makes sense to minimize the burden on City staff by augmenting their time and effort with volunteer labor.

Utilizing volunteer labor presents a unique set of challenges for any large organization, raising obvious issues of coordination and liability. However, in most cases, the benefits outweigh the costs, especially when volunteer tasks are clearly defined and well supervised. Large-scale introduction of Volunteer labor has been extensively employed and researched by the State Parks Department[47] and adapted by the East Bay Regional Parks[48] . Their exhaustive documents are available online to illustrate the value and demand of a successful volunteer program, and provide a useful framework for structuring volunteer action for our smaller purposes. Focused projects can often be organized using a specific waiver such as that employed in the Coastal Cleanup[49] or less formal creek cleanups.[50] Larger scale efforts can be shaped under an adaptation of the State Parks' plan, where volunteers are interviewed and specifically hired as unpaid employees for more complex work.

Three central areas have been outlined for initial volunteer action, but these could easily be expanded over time.

Beaver Docent Program

Using knowledgeable volunteers on site in the heavily trafficked weekend hours to answer questions about the beavers, inform the public and discourage unsafe/damaging behavior by humans. This has been happening informally on most weekends, and was coordinated for the duration of First Night. A guest book has been used to document the number of visitor's to the dam, and this is available for the city's viewing.

Willow Restocking Program

The goal is for a continuous restocking program of willow in the area. Native Willow is easily grown from cuttings and is often introduced for general bank stabilization. Newly planted trees can be fenced for protection, with older ones gradually "un-fenced" as their population is increased. Although there has been some suggestion of Aspen as a preferred beaver tree, it is not suitably zoned for this area of high wind and warmer temperatures.

Creek Clean-up Paddle Club

This has already occurred on an informal basis but could easily be organized on a bi-weekly schedule. Approved volunteers could sign up to Kayak the Creek on specific dates, removing trash and keeping the area clean. This is similar to the creek cleanups that already occur in the area, although it could be organized on a smaller and more frequent scale.

Worker's Compensation

When a non-profit engages in the hiring and supervising of volunteer labor they assume some responsibility for workers compensation provided that the injury occurred during the acceptable scope of their duties. For example, if a volunteer accidentally cuts themselves while trimming specified branches with city tools the volunteer may be entitled to worker's compensation. The Parks' Department Guidelines describe it thusly,

> *Workers' compensation insurance is a State mandated benefit provided by employers to their employees. Although volunteers are not state employees, they are covered under this program. This program provides compensation for physical injuries and other medically related disabilities occurring within the course and scope of the volunteer position. For example, if a properly trained mountain bike patrol volunteer, while performing his or her officially assigned duties, falls and breaks an arm, that injury will generally be covered by the Department's workers' compensation program. Each claim is reviewed on a case by case basis to determine eligibility.*[51]

Risk Management Strategies

Risk management strategies have been successfully adopted by many organizations. Here are those outlined by the State Parks Department:

> Some tasks performed by volunteers may involve the risk of on-the-job injuries. Risk management strategies should be incorporated into volunteer programs, including:
>
> • Proper supervision – effective supervision can lessen the risk of injury
> • Work as a team – some tasks are better suited to teams of 2 or more volunteers
> • Ongoing training – safe work practices and advanced training lessen risk to all staff and volunteers
> • Sign-in procedures – documentation of when a volunteer is on or off duty
> • Safety equipment – appropriate safety equipment and training in the proper use of equipment
> • Accident reports – all accidents and injuries must be reported and documented immediately
> • Ongoing analysis – both to prevent injury and to document the need for appropriate safety procedures

In many cases the City may want to reserve formal volunteer status for recurring or long-term volunteers that perform higher qualification acts like bank maintenance or habitat restoration. Short term clean-ups may be best served with the use of a waiver.

Tort Liability

Tort Liability refers to negligence law which requires a minimum standard of care for all workers of an organization, whether they are paid or unpaid. There is an implied standard for the quality of work done, and an organization can be liable if someone is harmed because these standards are not met. For example, if a volunteer was clearing a pathway and left a shovel which someone later tripped over, the city could be liable for that action. Again, this quote is from the State Parks' Volunteer Manual:

> As a representative of an agency, the actions of a volunteer may make the agency liable under the legal theory of *respondeat superior*. *'Respondeat superior'* is the doctrine that when a 'master' or agency acts through a 'servant' or employee, the master is responsible for the employee's actions. The perception of increased liability for volunteers led to the passage of the volunteer Protection Act by Congress in 1997.[52]

A decade ago this Act narrowed the responsibility of a volunteer in the event of a lawsuit provided that they were engaging in the action for which they were recruited and doing so in the appropriate manner. However, this law does not affect the liability of the organization which retained the volunteer, and they can still be liable for poorly trained or unsupervised workers.

As a result, the best advice for a supervising organization is to clearly define the role a volunteer is needed to fill, (i.e. "*plant willow cuttings along the eastern portion of the bank between Escobar and Marina Vista Streets*") to conduct interviews and reviews of potential volunteers so that problematic persons are prevented from the position and to have paid staff to supervise their participation on site. All of this may sound like an unattractive amount of work, but it is possible that this can reduce, rather than increase, the necessary city response.

The City of Martinez currently participates in the Public Education and Industrial Organization (PEIO) program of the Contra Costa County Clean Water Program. This is a regional project between the CCCCW and local cities, designed to raise awareness of watershed issues. A review of the 2006-2007 summary report[53] reveals the remarkable overlap between water quality efforts and beaver interests. PEIO goals with obvious similarities include 1) "*education of students, the general public and the business community about the effects of storm water pollution*" and 3) educating these about local watersheds by encouraging participation in "*ongoing creek protection and restoration*". The PEIO is an established coordination of community interests, volunteer effort and county oversight. It requires the city demonstrate community outreach and education, all areas met by ongoing maintenance of the beaver habitat. Successful stewardship of the Alhambra Creek Beavers is the expression of a larger commitment to the watershed and riparian habitat, and should be advocated as such.

In conclusion, there is compelling rationale for a volunteer program to maintain habitat and guide public interest. City liability can be avoided through waivers for shorter-term projects, and can be effectively managed through the development of a formal volunteer program for beaver

management. Time and effort invested by city staff may work towards other watershed goals and fulfill broader county commitments.

PERSPECTIVE #2

Worker's compensation, risk management and tort liability are significant issues which must be carefully considered regarding whether to maintain or not the beavers in Alhambra Creek. This will require consultation with the appropriate insurance, legal and risk management professionals. Included in the consultation should be the initial and long term costs associated with each component.

PROJECT COSTS

It became very clear to staff in early November of 2007 that this was turning into a major project. Dave Scola spent most of September and October (for which he submitted no time) researching beavers and talking to experts. Flooding was a major issue and contingency planning for such became very important.

Consistent with other programs, especially when there is no budget appropriation, the City Manager asked that staff keep track of their time. This was the case with Scola, Don Salts, Bob Cellini, and Tim Tucker. Time logs were kept by these staff starting in November. The City Manager has no reason to believe that what is presented here is anything other than salary and fringe benefits they earn for regular work time. No charges have been determined for overtime for these management personnel. If someone feels the need to come look at their notes, the City Manager suggests the parties be contacted directly. The time logs for service workers are available, and the City Manager can provide copies. This reflects regular and overtime work.

With respect to the question that somehow because these staff are salaried, we would be paying them anyhow; so, what's the point? The City is leanly staffed with less personnel per function than any of the cities around us. No time was allocated for beaver work this year, and thus, anytime spent in that function is taken from something else. It is fair and accurate to show what the costs are. It suggests nothing more than what has been spent.

As to the consultants, there are contracts in place or receipts for bills that have been paid. They are what they are. Those fees cover Skip Lisle, and PWA. It also includes time our contract City attorney has spent on the issue. The City will be spending more money to peer review the latest allegations submitted regarding adverse impacts caused by the beavers on adjoining property.

The City Manager understands there may be some out there who question the validity of these charges given something that happened at the marina years ago. The City Manager cannot speak to what happened in the past, only to what is happening now. All the staff who are engaged in this effort are people of incredible integrity. The City Manager has had the finance staff challenge and probe all that has been submitted, and it meets the professional and ethical test.

See Attachment Q.

GRANTS & OTHER FUNDING OPPORTUNITIES

Grant funding is available for multi-objective projects through mechanisms such as "Prop 84". Under this program, millions of dollars are targeted for the Bay Area. Grants applications are most successful when they are for multi-objective projects. The Martinez Beavers present the community with just such an opportunity. A project to coexist with beavers can protect from flooding, stabilize the creekbank, improve habitat, provide educational opportunities, and energize many segments of the community to work together. Successful grant application not only generates funding from outside the city coffers to do the project, but the very process of developing the grant application works to unify the community and broaden and maximize the benefits of the project.

A significant number of civic, environmental and educational organizations in the community have expressed their keen interest in participating in such a project. More are likely to join if the grant application process is initiated. Such a broad-based level of support is a very favorable characteristic for success in obtaining grants.

We have the basis for a very attractive project, strong and broad community interest, so we should go ahead and develop a "grantable" project then actively engage in a process to get grant funding.

LIABILITY

PERSPECTIVE #1

There have been a series of questions raised regarding retention of the beaver dam(s) in Alhambra Creek and the City's liability as a result of consequential damages. It is the opinion of a member of the subcommittee that the possible theories of liability, likelihood of lawsuits and judgments against the City should be addressed in a private litigation session(s) with the city council and its attorney, not by this Subcommittee.

Liability issues can present itself in a variety of forms and circumstances. The opinions that are expressed here are by a lay person and not from a qualified legal professional. Thus, the opinion expressed here is not dispositive on the subject of liability and should be addressed by the City Attorney through private litigation sessions.

PERSPECTIVE #2

In late 1999 Riverside County became concerned that a beaver colony was taking trees at their Lake Skinner Reservoir, which was part of the Metropolitan Water District of Southern California. The Department of Fish and Game was consulted and issued a depredation permit. They reported that this was necessary because destruction of habitat would negatively impact

two songbirds on the Endangered Species List that were known to breed in the area. (The Bell's Vireo & Southwestern Willow Flycatcher.)

A group of concerned locals (Friends of Lake Skinner) objected and sued the Department of Fish and Game, Riverside County Conservation Agency and the Metropolitan Water District, demanding that an Environmental Impact Report be obtained before the beavers were removed. They argued that under the regulations of the California Environmental Qualities Act an EIR was necessary. They lost this original suit and the matter was subsequently taken to appeal.

In December of 2000 the Fourth Appellate District overturned the original decision and ruled for the plaintiffs, stating that the decision to remove the beavers from the area was "discretionary" rather than "ministerial" and that because of this, there was a indeed a need for an Environmental Impact Report to meet the standards of CEQA. The matter was found for the plaintiffs and their entire costs were ordered to be paid by the defendants.

This lengthy proceeding lasted more than two years, involving three agencies and expensive expert testimony on both sides. This, ultimately, cost the defendants a great deal of money and public goodwill. A journal article was later developed regarding this action and was recently published in the Journal of Environmental Management 2007[54]. A copy of the remittitur regarding the Appellate Decision can be found in the appendix section of this report, and the article is included for your review.

PERSPECTIVE #3

The City of Martinez has handled itself well in terms of addressing perceived risk associate with flooding. The City put in place an emergency dam removal protocol, including a complete dam removal system. **The dam was asked to be removed, and it has been done by nature and would be done by the City if not.** The flow device also shows proactive movement on the part of the City.

It should be noted that the beavers' well-being was placed second to flooding concerns.
The fact that these measures were put in place when it could very well be unnecessary (as the wood and mud dam washed away naturally) shows the City took more that appropriate action.

All liability from potential flooding from the beaver dam is pretty much moot as the dam does wash away at one half creek volume.

As a further note other issues have been raised: e.g., does water in a creek create liability? This is presented in less than objective terms. Information has been given to an engineer that beaver activity is a potential cause of damage to buildings. The descriptions of the activity is exaggerated, unproven and stated to have occurred in parts on the creek that it has not and in some cases not relatively close the property of concern.

The majority of the buildings in this area are protected by substantial bank stabilization and erosion control, major steel and concrete walls. Some of which could be affecting the properties down stream in term of erosion.

Removal of vegetation by beaver can be characterized as a benefit to flood concerns rather than a threat to bank stabilization especially when beaver cut willow trees above the root line and sprouting occurs in spring. The root structure remains and if fact the tree is lest apt to be washed from the bank in heavy flows. All vegetation is not removed. Trees were also cut by property owners.

The engineer armed with partial information has ignored the fact that all these condition were pre-existing to the beaver, going back to the time before the building were placed in the flood plain and continue to occur as a result of increase flow due development upstream increasing scouring in the creek. Again, scouring of banks is less when there is a beaver pond.

Thoughts on liability should be shared directly with the City Attorney if that is proper. Do we really what to discuss a potential law suit publicly? I am aware of many reasons why this threat is weak. Can we, the Subcommittee, see the Assessment Agreement for the Creek Improvements? Attached is an email of humor that addresses something similar to our situation. Attachment R.

ECONOMIC IMPACTS

PERSPECTIVE #1

The fiscal impact to the City if the beaver dam(s) were to remain in Alhambra Creek necessitates a cost-benefit analysis. The City's expenses to date are reported to be between $70,000 and $100,000. At the sales tax rate of 8¼%, the sum of $82,500.00 is generated on every million dollars of sales attributable to the beavers. Unfortunately, Martinez only receives 1% of the sales tax rate, thus the City's share is $10,000 on every million dollars of sales attributable to the beavers. Consequently, the City would have to have minimally $7,000,000 in additional sales to break even for $70,000 of expenses.

There has been much talk and a great deal of speculation about the revenue that the beavers are generating for Martinez businesses. However, there has been no empirically documented information presented to the Subcommittee regarding this. As noted above, the City has expended money and staff time of between $70,000 and $100,000. This does not include the cost of future maintenance, staff time, or capital expenditure to modify Alhambra Creek to offset the loss of flood control capacity because of the existence of the beaver dam(s).

In conclusion, there does not appear to be sufficient justification on a cost benefit basis for the City Council to implement a plan to maintain beavers in Alhambra Creek.

PERSPECTIVE #2

The economic impact of the beavers to Martinez cannot be simply expressed in the tax revenue generated by the presence of the beavers. If such criteria were universally applied, civic improvements to downtown would never have been made. The attractive use of pavers for the sidewalk, the planting of street trees, and the new and improved lighting would not have been done. Such improvements are intended to stimulate visitation to downtown Martinez. If the

calculation of minimally required increases in sales as described above is applied to such projects, they could not be justified and nothing would ever be done to improve the situation. Martinez did make these improvements, and the consensus is that this was a good thing to do. The same kind of justification that Martinez used to make these improvements to downtown should also be used for the beavers.

The value of the beavers to Martinez economics goes much beyond the sales tax revenues generated for the City. The way we handle the beaver situation can have a strong and profound influence on the image that Martinez projects to the rest of the world. The beavers have elevated Martinez to a level of prominence that would be the envy of any municipality. Many cities and businesses are working to portray themselves as "green". Martinez, the home of John Muir is also starting down this path. What better symbol of "green-ness" can we ask for than to demonstrate to everyone that we can find a way to coexist with the beavers in our downtown and do this in a way that protects the downtown from flooding and capitalizes on the beaver as a civic amenity. We have been handed an opportunity, it is up to us to make the most of it.

One reason the beavers have increased visitation to the city is because they have increased the city's visibility. With the sustained interest in the beavers and the dynamic civic response, there have been primetime news casts on virtually every major channel featuring images of the city and the opinions of its residents. One tool for evaluating this fiscal impact is to consider the cost of city advertising on any of these channels during peak viewing hours.

For example, KTVU was contacted and reported an ad rate of $2500.00 for the first 30 seconds of air time. Consider this against the press the beavers have generated for the city since November. Looking only at TV time and setting aside radio and newspaper coverage, major news stories have aired November 6th, December 5th, December 18th, January 4th, and January 28th. Each of these were at least 30 seconds in length, usually 3-5 minutes, and typically repeated morning noon and night. News clips from KPIX are still available online and show cumulative air time of 22 minutes. According to the KTVU advertising rates they represents an approximate value of 25,000 worth of advertising, repeated 3 times a day for 75,000 and expanded to 5 major channels. The conservative estimated value runs more than a quarter of a million dollars in advertising alone. And in every instance, the beavers, not the City, picked up the tab.

PUBLIC RELATIONS

Summary

The beavers have had an undeniable impact on the visibility of Martinez. Many residents who have never heard of or visited our city have been lured closer by news stories on every major TV and radio station. There are a multitude of options for public relations use of the beavers, from education to tourism to publicity. A large scale documentary is already underway and will be featured on the Discovery Channel next year. Students from as far as Sacramento are making fieldtrips to the dam site. A progressive, humane and committed management plan for the

colony will not only demonstrate the compassion and community spirit of the City, it will also broadcast our ingenuity, pragmatism and know-how.

Publicity

Many residents who have never visited our city have been lured closer by news stories on every major TV and radio station[55]. There have been visitors to the dam from other Bay Area Cities, such as Berkeley and San Francisco, but also from farther reaches such as Half Moon Bay, Sacramento and Napa. Some use Amtrak to visit and this is a natural link to the area. Many families have brought out-of-state visitors to see the beavers from such distant places as Hawaii and Florida. The most watched Youtube video has now been seen by nearly 6000 people. The Martinez Beavers were featured in the award winning magazine "Bay Nature", and in the Winter Newsletter of the New York advocacy group Beavers: Wetlands & Wildlife.

Since its launch in December, the beaver website (___@___) has generated increasing traffic over the past months and is currently receiving nearly 500 hits a day. All interested participants can be encouraged to consider guest-blogging. Since the Martinez Gazette is not yet available online, a reasonable development would be the posting of Beaver-related stories on the website, either in full or in part. This could help boost Gazette sales and increase information on the Beavers. In recent weeks there has been expressed interest by the Humane Society and the Sierra Club as there is a growing sense in the Beaver-savvy community that the Martinez Beavers may spearhead a campaign for beavers in the larger California Area. While urban and wild areas increasingly overlap, there is a growing need for positive models of pragmatic, humane management. Martinez is poised to be a leader in this area.

Marketing

All of this activity generates interest in and revenue for the city. Marketing opportunities include the following:

- Recently an effort was suggested to use "calling cards" when making downtown purchases to indicate that buyers were in the city to visit the beavers. This simple technique is often used by the Audubon society to express support for wildlife viewing opportunities.

FRIENDS OF THE
MARTINEZ BEAVERS

I made this purchase today
while visiting the
Beavers of Alhambra Creek

Thank you!

*Name:*_____
Date: _____

- The Chamber of Commerce has been contacted with the intent of developing an informative map for visitors to the area, showing the location of the lodge and dam and conveniently listing restaurants and shops.

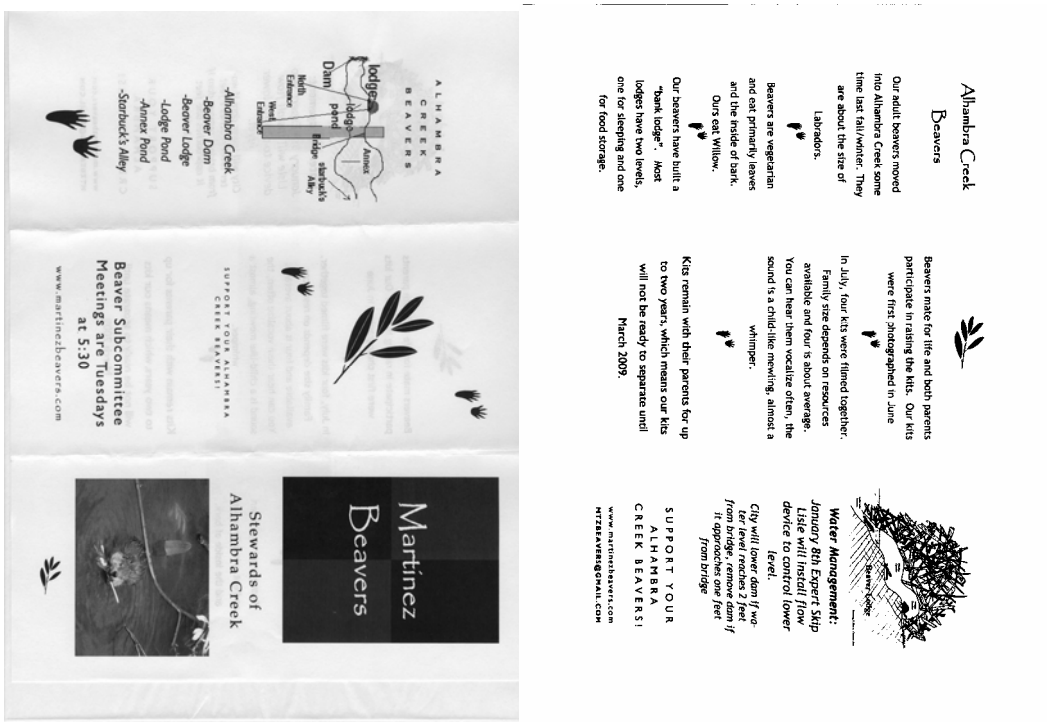
- A volunteer "beaver docent" program during peak hours can help answer questions at the dam and clarify beaver behavior for visitors. See Volunteer Engagement.

- This year's First Night saw the successful sale of a stuffed "Martinez Beaver," giving some indication of the amount and direction of community interest. Beaver t-shirts are a regular feature in downtown shops already but could be augmented to include raising money for maintaining the beavers themselves.

- Postcards or note cards of the beavers would be an effective way to raise awareness of Martinez' role in preserving this unique resource.

- Further developing the link between the John Muir Site and the Beavers can augment use: already the Muir site says they are seeing an increase in first-time visitors asking for directions to the Dam. Amtrak recently added a John Muir guide to every seat on their San Joaquin line; this could be a way to add Amtrak information to the Martinez beavers.

- Beaver information is already being distributed in the form of this pamphlet which outlines their story and behavior. This type of resource can be regularly updated as new information becomes available. The printing and distribution of this pamphlet has been made possible by volunteers, and this could easily continue. Other financial contributions could happen through the non-profit organization or through advertisements by local business added to the flyer. Logical sites for distribution include downtown shops, the John Muir House, and the Amtrak station.



- Interested residents could be involved in updating content, and an excellent project might be a contest for student artwork or essays that could appear in the brochure. Unselected entries could appear on the beaver webpage or in other venues.

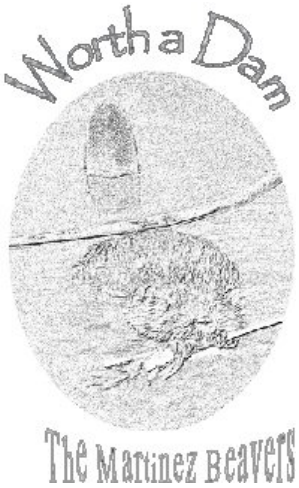
- An organization has been established which can coordinate resources and financial support for the beavers. "Worth A Dam" is an unincorporated association which can receive donations for the beavers and centralize community support. In order to quickly secure nonprofit status, a receiving relationship has been developed with "Land 4 Urban Wildlife" which is a Pleasant Hill based 501(c) that is associated with Friends of Pleasant Hill Creeks. Tax deductible donations will be received through a Paypal account on the Martinez Beavers webpage and these monies can be used for maintenance of habitat or expanding public awareness.

  "Worth A Dam" will be maintained with the following appointed officers:

  President: Heidi Perryman
  VP-Public Relations: Linda Meza.
  VP-Wildlife: Cheryl Reynolds
  CFO: Donna Mahoney.

Worth a Dam:
The Martinez Beavers

Maintaining the Martinez beavers through responsible stewardship, creative problem-solving, and community involvement.



Monies could be moved towards habitat restoration, publicity and ongoing upkeep. There have already been several offers of donations from various cities already.

Media Opportunities

Other opportunities for making the public aware of the Martinez beavers include visual media. The Martinez Beavers will be featured in the documentary series "*The Concrete Jungle*", by Don Bernier and Rachel Buchanan, which will air on the Discovery Channel this year. Don has already filmed the site, Council and subcommittee members several times, and attended the November 7th City Council Meeting. The documentary will be an international look at the overlap between wildlife and civilization and has been recognized by the Humane Society of the United States thusly[56]:

> *With all four HSUS/ACE[57] finalists facing the challenge of pitching their projects to a panel of seasoned development and production executives from PBS, Animal Planet, National Geographic Channel International and Porchlight Entertainment, The Concrete Jungle emerged as the strongest contender for broadcast with its intriguing look at the wildlife residents of urban settings ranging from New York to New Delhi to West Africa, as seen through the eyes of the people serving on the frontlines of this complex international problem.*

Specific media interest, such as Bay Area Backroads, has already expressed an interest in the beavers, and a willingness to feature them once their fate is settled. Natural points of elevated media attention include the birth of kits, the rainy season, and related species that come for the habitat. Ultimately Martinez may wish to market a video for purchase including footage of the beavers, the dynamic November 7th meeting, and interviews with interested residents and Council.

CALIFORNIA
WATCHABLE
WILDLIFE

More formal advertisement of the beavers' presence could come from nominating the dam for a "Watchable Wildlife" inclusion. This is a nationwide organization with a California Chapter comprised of representatives from many bureaus[58]. A site is included based on its accessibility from major thoroughfares and the accessibility of the site in general; the uniqueness of the animal being viewed, and the likelihood of visibility by the public. Designated sites are included on their web page and regional itineraries, and marked with these highly visible signs on nearby freeways. Information about the nomination process is available at their website here: http://www.cawatchablewildlife.org/index.html.

As is evident, there are a multitude of options for public relations use of the beavers. Our integration of these animals into the downtown area can augment the visibility of a city whose charms have recently gone largely unnoticed. A progressive, humane and committed management plan for the colony will not only demonstrate the compassion and community spirit of the city: it will also broadcast our ingenuity, pragmatism and know-how. If we do this right, we will serve as a model for other interested communities[59] nationwide. Our beaver management plan should be added to the city web page for others to copy and imitate. Ultimately, we may wish to add the position of Watershed Steward at the city or County Level, as other areas have done[60], to successfully monitor water quality and habitat issues.

MANAGEMENT STRATEGY

PERSPECTIVE #1: "MANAGEMENT CO-EXISTING WITH WILDLIFE"

The idea of Martinez having to decide eliminate, remove, any form of wildlife, put in the best light, is confusing. One would guess this would baffle a majority of Martinez residents. The proof is on record in our city's historic support of Parks, Open space and the Alhambra Creek itself.

Wildlife has played an important role in the history of Martinez in many ways. It has and continues to sustain human life and economies, both commercial and recreational, and continues to be part of our community fabric. A significant contribution to the Martinez quality of life is the presence of wildlife. Wildlife is sacred to many people who live in Martinez.

Coexisting is the only palatable option and is substantiated in the fact we have solved almost all concerns perceived or otherwise, flood risk being at the top of the list as in fact the dam washed out at one half the creek volume during a medium rain fall.

Another concern was water level and that has been put back to status quote e.g. tide level. Any concerns left can be solved as well at little expense, something akin to filling a pot hole, or installing a fence.

Management of all wildlife should be the same, HANDS OFF. With maybe the exception of what the city has already done in terms of negating the flood risk, by installing a breakaway system and lowering the dam.

The city should do some more flood mitigations as the creek has **filled pre-beaver** at the dam site and below. The flood plain above Maria Vista Bridge should be widened at the dam location and an elevation above the dam to take advantage of flow volumes above high tide elevations. This can be characterized **not** as a beaver caused condition, but something **the beaver have reminded us** to do, monitor the creek.

The cost to keep the small band of friends is already off set by the benefits we have gained and there is more come!

EDUCATION

Management should be captured in this phrase:

These Particular Beaver In This Particular Creek At This Particular Time!

See Sierra Club letter in support of keeping beavers. (Attachment S.)

PERSPECTIVE #2

Perspective #1 is not an objective analysis of Beaver management options vs. removal, but rather a biased advocacy for maintaining beavers in Alhambra Creek.

PERSPECTIVE #3: SUMMARY

The starting premise of the Strategy is that any solution that is chosen must provide a level of protection at least equivalent to "pre-beaver" conditions.

The advent of the beaver dam in downtown Martinez presents the community with both an OPPORTUNITY and a PROBLEM.

The salient question is: *Can Martinez find a way to co-exist with the beavers, reap the benefits of their presence, and still protect itself from flooding, maintain soil stability and water quality at "pre-beaver equivalent levels"?*

The proposed answer is: *Yes, solutions to the problems are available if we are willing to make them work. A combination of features from several options can improve flood protection above the level experienced "pre-beaver"*

A number of options have been advanced that can achieve the simultaneous goals of flood and stability protection, water quality and beaver co-existence. A preliminary evaluation of these options has been done and a recommended option is offered. This option will provide a level of flood protection above the pre-beaver level, will allow continued coexistence with the beavers and will be capable of being integrated into future larger-scope flood protection improvements.

Opportunity

The unique quality of the Martinez Beavers is their visibility, accessibility, and tolerance of being visited by numerous humans. This combination of beavers and visibility is very rare, even though beavers, in general are not rare. The beavers have attracted unprecedented attention to downtown Martinez. Beaver-related publicity has been achieved that can rarely be equaled even by high-priced publicity campaigns. People are coming downtown to see the beavers. They are spending money here. The whole thrust of wanting to revitalize downtown has revolved around "getting more people to come downtown". From this perspective, the beaver attraction can be seen as a dream come true. Martinez, as the home of John Muir, aspires to be an "environmental" destination. Demonstrating an ability to coexist with a family of beavers downtown can be a powerful force supporting our status as a "nature-friendly" community.

Martinez has a proud track record of honoring and preserving and protecting open space and wildlife habitat. These values are built into the Martinez General Plan. Wildlife has played an important role in the history of Martinez and continues to be part of the community fabric. A significant contribution to the Martinez quality of life is the presence of wildlife.

The visibility and willingness of the beavers to be observed also presents many opportunities for education, especially education that addresses the "Nature deficit disorder" syndrome. School groups are already using the beaver location as a destination for field trips and as a subject for study. The presence of the beavers has stimulated an already active volunteer movement in support of Alhambra Creek. These topics are covered more extensively in the Educational Opportunities and Volunteer Engagement sections of this report. References to the benefits of nature-based learning are contained in the appendix of this report.

The effect of beavers on wildlife in the Martinez downtown has not been formally investigated, however, experiences at other locations indicate that generally the net effect of beavers on wildlife is positive. In Oregon, coastal streams with beavers sustain greater populations of Coho Salmon than comparable streams without beavers. This subject is covered more extensively in the Impacts on Other Species and Environment section of this report and in the appendix to this report.

Problem

Flood Risk: Many factors affect flood risk, bank stability and water quality. Many of these factors are not related to beavers. This report does not attempt to explicitly address the full range of contributing factors but focuses primarily on those that are perceived to be related to beavers.

Beavers, left to their own devices, like to build dams that flood ever-increasing areas to improve their access to food and for protection from predators. If left unchecked, the beavers have demonstrated an ability to build a dam that reduces the capacity of Alhambra Creek to convey water. This kind of reduction of capacity potentially increases the risk of flooding in downtown.

Beaver dams are known to wash out in high-flow events. Attempts to use beavers as a restoration tool in non-urban areas have been reported to typically wash out approximately twice as often as they do not. Experience during the 2007-2008 rainy season tends to support this idea: some portion of the dam washed each time the water flow crested the dam. The degree of washout appears to be roughly proportional to the magnitude of the flow. The largest storm of the season, in early January, did indeed wash out most of the dam. Lesser storms resulted in smaller washouts. Based on such experience one might postulate that the odds are in favor of the beaver dam washing out and not increasing flooding risk.

Downtown property owners, along with the community as whole, have invested significantly into a project to protect themselves from flooding and deserve to have the level of protection that the project was designed to deliver. They have a right to more assurance than "the odds are in favor" of not flooding due to beavers. Therefore, simply leaving the beavers alone and counting on the dam washing out is not a viable option. The situation must be appropriately managed.

To manage the situation for the present wet season, Cables and anchors have been installed to allow rapid removal of the dam if necessary. City crews are put on alert for approaching storms and are poised to monitor water levels and systematically dismantle the dam as needed to prevent water rise above a set point (well below flood level).

In consultation with hydrologists and beaver management consultants, it was decided that the dam also needed to be controlled at a lower height to increase the margin for the city crews to respond.

Left to their own devices, if the dam is simply lowered without applying management techniques, the beavers tend to build it back up to the original height again. To prevent the beavers from doing this, a pond-leveling device was installed. The pond leveler or "Castor Master" is a pipe which takes water from the bottom of the pond and routes it over the dam. The beavers rebuild the dam as high as the pipe, but not higher. Thus, the height of the pipe sets the

height of the dam. This device has worked as intended and the beavers have not rebuilt the dam above the level set by the City.

These measures have been sufficient through most of the 2007-08 wet season, however, this situation may not be sustainable. City crews have a lot to do in response to storms, and adding one more set of jobs and responsibilities on a permanent basis during this high-activity time is not an attractive long-term solution. A more permanent and comprehensive solution needs to be found. A range of such solutions is described in the Hydrology/Flood Management section of this report.

Proposed Solution

By combining features of several options, a solution has been developed that enhances flood protection above the pre-beaver case and allows continued coexistence with the beavers. (See Hydrology/Flood Management).

This solution combines the Flood Terrace, Flood Wall and Controlled Overland Release options into an integrated solution which will protect against flooding from the creek rising, will improve the drainage of Castro Street and will accommodate the beavers. From a flood protection perspective, this comprehensive solution is a good idea regardless of whether the beavers are there or not. The presence of the beavers opens up expanded possibilities of funding from sources other than city coffers.

This solution combines several components, which when executed together work in a synergistic manner to enhance flood protection. Please see Figure 1 attached for reference. The walls are shown in yellow, the excavation in green and the controlled overland release in blue.

1. Fill in the gap in an existing wall on the East side above Escobar bridge and tie into the bridge superstructure.
2. Build a wall on the West side above Escobar to tie in the bridge to the existing high ground.
3. Extend the existing wall on the East side between Escobar and Marina Vista and tie into the Marina Vista bridge.
4. Excavate a flood terrace on the West side between Escobar and Marina Vista.
5. Install a flood wall on the West side between Escobar and Marina Vista
6. Lower the elevation of the intersection of Castro and Marina Vista to allow free flow between Castro and a re-entry to the Creek below the Marina Vista Bridge.
7. Construct a robust re-entry point below the Marina Vista Bridge.

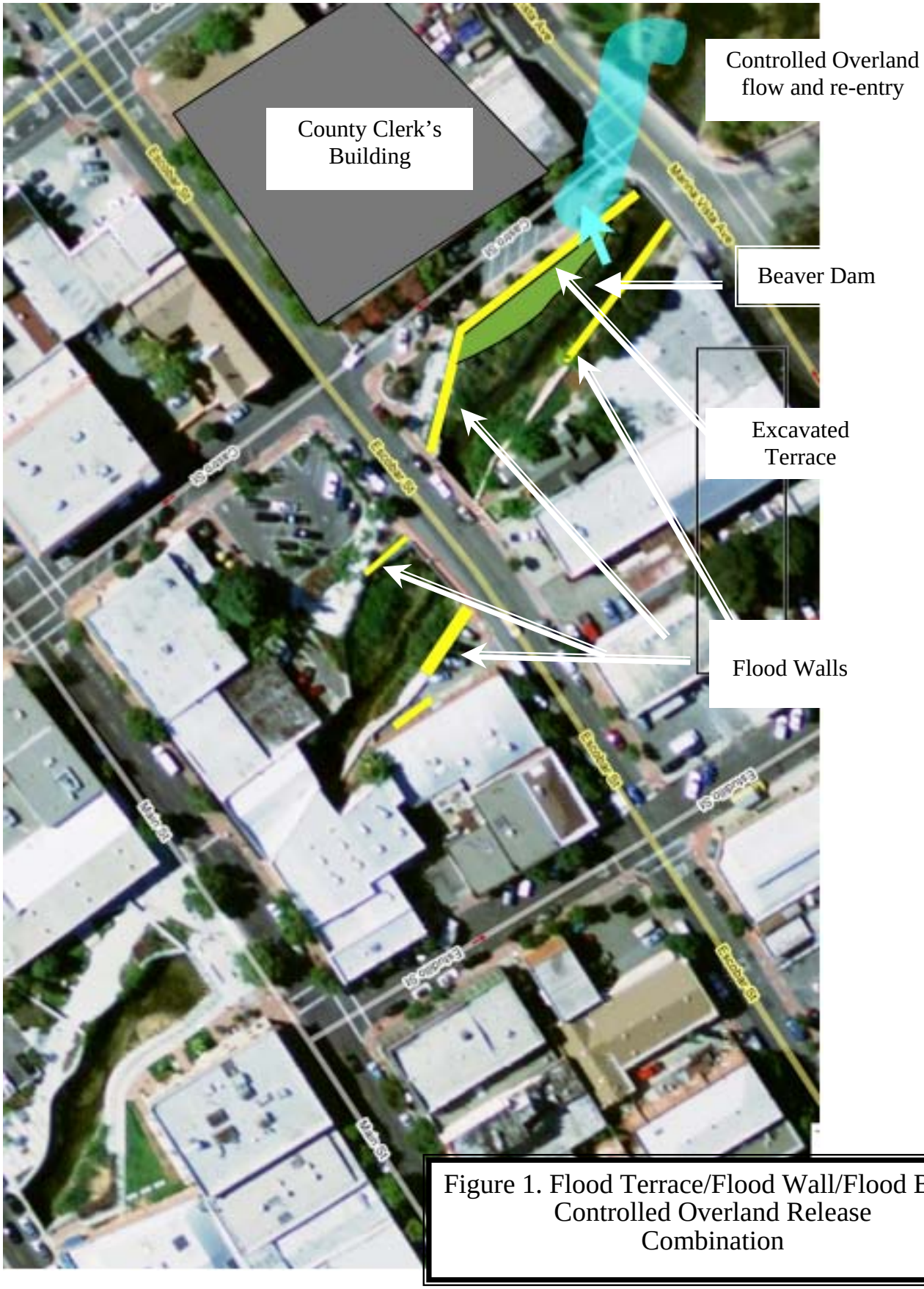


Figure 1. Flood Terrace/Flood Wall/Flood Berm/ Controlled Overland Release Combination

Bank Stability: Property owners along the creekbank have expressed a concern about tunnels undermining their structures. During the "castor master" work, City crews found four tunnels in the East bank of the Creek. It is unclear whether beavers or muskrats are responsible for these tunnels, however, the solution is the same. Tunnels can be prevented. Successful countermeasures have been applied at other beaver sites. They are described in the Bank Stabilization /Burrowing section of this report.

Another concern expressed on behalf of creekside landowners has been the possible effect of a rising water table in the soils adjacent to the beaver pond. Water-saturated soils behave differently than dry soils and concern has been expressed regarding the effect of increased water saturation on the stability of buildings.

The situation at the Martinez beaver site is not clear-cut. The area is characterized by unconsolidated soils, which tend to be unstable. The tides also influence soil moisture twice a day. Also, the concern was expressed at a time when the beaver dam was at its highest level. Therefore, it is unclear if the perceived instability is due to the presence of the beaver dam at its present height or is a characteristic of the location. These questions cannot be answered without a technical investigation, conducted by professionals versed in this field. A more detailed discussion of this topic is presented in the Bank Stabilization/Burrowing section of this report.

Water Quality: A concern regarding the effect of beavers on water quality has been expressed. The main focus of this concern is the visual appearance of the water in the channel at the Creekside Plaza between the Bank of America and Starbucks. Anecdotal reports of "turbid, scummy" water have surfaced.

A previously conducted watershed-wide water quality sampling/testing program which included this site has shown that Alhambra Creek water quality is highly variable, changing primarily in response to temperature and water flow. That program was concluded prior to the advent of the beaver dam. A sampling and testing program based on a more focused version of the previous program is proposed to determine if the perceived water quality problems are associated with the beavers or are pre-existing in the watershed independent of the beavers. This topic is discussed more fully in the Water Quality section of this report.

The salient question is: Can Martinez find a way to co-exist with the beavers, reap the benefits of their presence, and still protect itself from flooding, maintain soil stability and water quality at "pre-beaver equivalent levels"? The proposed answer is: Yes, if we are willing to make the investment in making the solutions work.

Addressing the problems

Protection from flooding

- Seven options are discussed in the Hydrology/Flood Management section of the report. These options should be evaluated on the basis of the following seven criteria to select the Preferred Option:

    1. The solution must provide at least "pre-beaver equivalent" flood protection, stability and water quality.

2. The solution should have as little adverse effect and disruption to the beavers as feasible.
3. The solution should be sustainable, without requiring extraordinary ongoing effort to manage and maintain the solution's functionality.
4. The solution should maintain the natural hydrologic function and appearance of the creek to the greatest extent feasible.
5. The solution should capitalize on the educational, economic and life-quality enhancement opportunities obtainable by the presence of an accessible and visible working beaver colony in downtown Martinez.
6. The cost effectiveness of the solution should be evaluated based upon the implementation and maintenance costs balanced by the civic, commercial, educational, economic and life-quality enhancement opportunities.
7. To the maximum of feasibility the selected option should be capable of being integrated into a potential future more comprehensive solution.

- The preferred option's cost should be identified and financing options should be explored and project partners should be sought.

  - With the project, by definition, being a multi-objective solution, multiple funding sources would be available that are not available for single-objective (flood control) projects. (See Grants and Other Funding Opportunities)
  - Funding from multiple sources such as achieved for the combination of projects to enhance the creek and protect downtown from flooding that has already been built would be available, so City funding could be extensively supplemented from other sources.

Protection from burrowing

- Countermeasures such as covering the bank with wire-mesh fencing material have been employed at other beaver sites and are recommended by the "Beaver Consultant" retained by the City. (See Bank Stability/Burrowing)
- This countermeasure should be evaluated against others using the evaluation criteria and a preferred alternative selected.
- Install the preferred alternative.

Soil stability

- Perform an engineering study to evaluate the effect of the beaver dam at its present lowered elevation to determine if any change has occurred due to the presence of the dam. . (See Bank Stability/Burrowing)
- Follow up appropriately, based on the findings of the study.

Water Quality

- Conduct a water quality testing/sampling program as described in the Water Quality section of this report.

- Follow up appropriately, based on the findings of the study.

Reaping the benefits

- Educational Opportunities
  - Develop signage, trails and observation sites
  - Develop curricula
  - Publicize research opportunities
- Commercial and Civic Opportunities – use the free publicity enabled by the beavers and the community's response to them to promote Martinez as "The City that Figured it Out."
  - Incorporate beavers into existing festivals or make one based on beavers
  - Develop tours featuring beavers
  - Engage the community in volunteer efforts in connection with the beavers
  - Develop brochures featuring Martinez as an Environmental Destination using Beavers, John Muir, City and Regional Parks/Trails and Alhambra Creek as featured attractions.

Extending the benefits

The presence of the beavers in downtown Martinez has brought unprecedented attention to bear on the Alhambra Creek Watershed and on the Martinez community. This prominence provides an opportunity to generate momentum to address larger watershed issues. Such as

- Flooding from upstream of the Downtown Project
- Flooding from surrounding slopes.
- Improve general flooding protection better than the present level.
- Water quality issues from septic systems, storm drains, trash and other non-point sources
- Make the creek enhancements described in the General Plan Amendment: The Alhambra Creek Enhancement Plan.
- Developing a long-term plan to provide sustainable flooding and erosion protection.

Martinez has an existing Creeks Committee that has completed its original charter. It worked only within the city limits of Martinez. The issues are best addressed on a watershed-wide basis. This Committee can be reconstituted with a broader mandate and an expanded membership and can set to work to address these issues. Such an integrated, cooperative initiative can have profound beneficial effects on the entire community and watershed.

OTHER OPTIONS/ Relocation

Summary

Sherri Tippie of Colorado has a reputation of being the best-known beaver relocator in the country. She was contacted regarding the Martinez Beavers in early November. Moving a colony is a complex and risky process. Cases where it is most successful involve the use of Hancock traps, a beaver-knowledgeable quarantine plan, the synchronized introduction of family

members, and an ideal new habitat with desirable food sources. Simply catching and relocating the beavers is no guarantee of their survival. The best time of year for beaver relocation is fall, when kits require less care. Since the female in the Martinez colony is currently pregnant, now would be the **wrong** time for relocation.

Permits

The California Department of Fish and Game does not typically allow beaver relocation. Specific exceptions have been made in the past for reintroduction of beavers into specific habitats where they are no longer represented.[61] Other exceptions include SCP permits which allow removal for scientific purposes.[62]

> The SCP does **not** authorize animal relocation for non-scientific purposes. The SCP is not appropriate to authorize relocation of animals as part of California Environmental Quality Act (CEQA) mitigation or movement of animals "out-of-harm's way". Relocation authorization for CEQA mitigation must be obtained by contacting the local DFG regional office prior to handling or relocating wildlife.

A specific exception was granted in the case of the Martinez Beavers. The Department of Fish and Game said they would issue a permit to allow relocation provided that the animals underwent a period of quarantine. The Lindsay Museum volunteered to take on responsibility for this.

Live Trapping

The SF Chronicle reported that the City would hire an experienced live trapper and that this contract might be as much as $10,000[63] . The article referred to "tracking down an expert in the Colorado area," which was later revealed to be Sherri Tippie[64] . Coincidentally, Ms. Tippie was contacted the day of the November 7th meeting to learn about the risks and benefits of relocation and her availability for such a project. Notes on that conversation were provided to the Council that night by resident Heidi Perryman. Additionally, at the November 7th meeting, a representative from the Mountain Maidu Tribe of the Greenville Rancheria of Plumas County offered to receive the beavers. The best-known beaver relocator in the country is Sherri Tippie of Colorado[65].

Ms. Tippie has worked with Skip Lisle in the past and is well known to the beaver community. She has been interested in the Martinez beavers since their story made the headlines in November, and has responded to email and phone questions over the past three months. Ms Tippie indicated that she would be willing to come and relocate our beavers, but noted that this would mean driving out to carry her cages and traps. She reported that the trapping could take place over 2-3 days, and that she would need to stay near the site to make sure a caught beaver did not remain in the trap too long. She advised that the best time to relocate beavers is the fall, (when kits begin to require less care) and noted that since our mother beaver is likely pregnant now would **not** be an appropriate time for relocation[66].

Certainly the option of relocation was much more attractive to the general public than that of extermination. However, animal relocation is more complex than it sounds. Successful trapping requires specialized equipment and knowledge. It can take several days to capture an entire

family and then the animals must be relocated as a unit. The most widely used technique of snare-trapping can cause internal injuries that ultimately lead to the animals' death[67]. Hancock traps, which are like giant mesh suitcases, have been shown to be the safest[68] . However these are heavy (33 lbs), costly[69], and fairly difficult to use. Even under experienced handling, the beavers are vulnerable to problems with temperature regulation. The trap pulls beavers onto the bank to and this can mean they are overheated by the time they are recovered. Other risks of the trapping process include accidental trapping of other animals, such as otters or dogs, and possible drowning due to sudden flooding.

The Sierra Club opposes relocation as a management tool for our beavers, writing that the science is not adequate for predicting which habitat would be a more appropriate replacement venue. In fact, often animals do not survive relocation attempts. In the well-documented case of Lake Skinner the Department of Fish and Game relocated 13 animals with questionable success.[70]

> *Thirteen beavers were trapped live and removed, one died struggling in a snare, and one was killed by a predator while held in a snare… Six beavers were confined in zoos or other captive display facilities (one beaver subsequently died in a fight resulting from inappropriately co-housing two males), four were relocated to a reserve in Texas, and three went to a movie production company. The trapping was complete by spring 1999.*

As the above paragraph notes, even after successful, humane trapping, animals can be killed by the well-intentioned mistakes of those who care for them. Ms. Tippie stressed that quarantine conditions are particularly dangerous to beavers, and that animals are often killed due to a misunderstanding of their needs. Often families are introduced to the new location over several days, but individuals never wait around to learn that their colony mates will be rejoining them. Kits younger than 2 years may separate from their parents before they are ready and face dangers without adequate survival knowledge.

Despite the feeling of palpable relief expressed by residents after permission was given to relocate, moving a colony is a very complex and risky process. Cases where it is most successful involve the use of Hancock traps with a skilled relocator, a beaver-knowledgeable quarantine plan, the synchronized introduction of family members, and an ideal new habitat with desirable food sources. Simply catching and relocating the beavers is no guarantee of their survival.

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List of Attachments

Attachment A: PWA March 18, 2008 report
Attachment B: Beaver Dam Information Site
Attachment C: The Beaver Natural History of the Wetlands Engineer, page 110
Attachment D: The Beaver (Castor Canadensis)
Attachment E: General Plan May 1992, "The Alhambra Creek Enhancement Plan."
Attachment F: The Beaver Natural History of a Wetlands Engineer, page 121
Attachment G: "How Do Beaver Affect Local Hydrology on a Watershed in South Alabama"
Attachment H: Alhambra Creek Enhancement Plan
Attachment I: Chapters 15 and 14 of the "Downtown Specific Plan,"
Attachment J: Muskrat and Beaver Management In Wetlands: Planning Ahead for Wildlife Survival
Attachment K: http://www.beaverdam.info/ site
Attachment L: The Beaver Natural History of a Wetlands Engineer, page 126
Attachment M: Otto and Johnson's Beaver Influence of Fisheries Habitat
Attachment N: The Beaver Natural History of a Wetlands Engineer, pages 88-91
Attachment O: http://www.cnaturenet.org/research/volumes/C16/16 Title: Children & Nature Network -
Attachment P: http://heapro.oxfordjournals.org/cgi/content/full/18/3/173 Title: Health Promotion International, Vol. 18, No. 3, 173-175, September 2003
Attachment Q: Staff Costs
Attachment R: Email
Attachment S: Sierra Club letter

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MEMORANDUM

Date:	March 18, 2008
To:	Timothy Tucker
Organization:	City of Martinez, Engineering Department
From:	Mark Lindley, PE
PWA Project:	**Martinez - Alhambra Creek Beaver Dam Assessment (1823.02)**
Subject:	**DRAFT Alhambra Creek Beaver Dam - Management Options**
Copy(ies) To:	

Introduction

Philip Williams & Associates (PWA) has assisted the City of Martinez (City) on issues related to flood management and habitat enhancement over the past 15 years. The City has implemented several projects since 1998 to improve flood conveyance and habitat values along the Alhambra Creek corridor. The Downtown Improvement Project included widening the creek corridor, creating a floodplain bench, and widening a number of bridge crossings between Marina Vista and Green Street. At the Intermodal Facility, a wide marsh-plain bench was created adjacent to the low flow channel and the Southern Pacific railroad bridge (SPRR) was replaced with a longer span with a higher bridge deck. Finally, the Salt Marsh Enhancement project at Grainger's Wharf included widening the creek corridor, creating marsh-plain benches adjacent to the channel, and providing a secondary outlet for discharge of high flows to the Carquinez Strait. Collectively, these projects have improved flood conveyance in Alhambra Creek from about the 2-year peak discharge to approximately the 10-year flood event (PWA, 2000). While these improvements have provided a decrease in flood hazards, much of the city is still vulnerable to flooding during extreme rainfall-runoff events.

In 2006, several beavers relocated to Alhambra Creek constructing a dam in the downtown reach of the channel between Escobar and Marina Vista Streets (Figures 1 and 2). PWA assessed the potential effects of this beaver dam on flow conveyance and flood elevations in October 2007. The results of that initial study indicated the beaver dam could increase flood risks along Alhambra Creek within the downtown Martinez. The City requested that PWA develop management strategies to mitigate increases in flood risks while maintaining the beaver dam. This memorandum provides several options to manage flood risks while maintaining the beaver dam at its current location.

3. Develop an active flood response plan using rainfall measurements to alert City staff of the need to remove or lower the beaver dam during an extreme event.

Management Option #1 – Maintain Lower Dam with Flexible Leveler

Lowering the beaver dam would increase conveyance to help mitigate increases in flood risks. However, based on the City's experience to date, the beavers tend to rebuild the dam up to and possibly higher than the original dam height. The City contacted Skip Lisle from Snohomish County, Vermont to install a flexible leveler ("beaver deceiver") to allow the dam to be maintained at a lower height. The flexible leveler penetrates the dam with a flexible culvert that mimics the sound of water flowing through and over the dam at full height (Figure 4). This affects the beavers response, allowing the dam to be lowered by up to 2 to 3 feet.

To aid in the estimation of a beaver dam height with lower flood hazards, PWA examined the dam under three scenarios – lowering the dam crest by one, two and three feet from the October 2007 crest elevation. Using the same approach described in our October 16, 2007 memorandum, we initially estimated conveyance using a flow-area analysis. In addition, we updated the HEC-RAS model of the downtown reach of Alhambra Creek to more accurately estimate conveyance and flood elevations.

Flow Area Analysis

The flow-area analysis involved calculating the channel cross-sectional area of the original design section at the beaver dam, the reduced flow area with the beaver dam, and the flow area with the dam lowered one, two and three feet. To compute flow capacity we utilized the velocity at this cross section obtained from the HEC-RAS hydraulic analysis which was assumed to remain the same for each scenario studied. The capacity at the Marina Vista Avenue Bridge was also calculated based on the velocity from the HEC-RAS hydraulic analysis at the bridge for reference. The Marina Vista Avenue Bridge is the next hydraulic constriction immediately downstream of the beaver dam, and may affect channel capacity at this location. Results from this analysis are presented in Table 1 below:

Table 2: Peak Flow Rates at Southern Pacific Railroad Bridge

Return Period	Peak Flow
	(cfs)
2-year	634
5-year	1600
7-year	2000
10-year	2400
25-year	3618

Hydraulic modeling results are presented in Figures 5 through 7, comparing modeled flood elevations with and without the beaver dam in its October 2007 condition and lowered by one, two, and three feet for the 2- through 7-year return periods. The modeling results indicate that the level of flood protection along this stretch of Alhambra Creek is decreased to less than the five-year flood event with the beaver dam (i.e. the chance of flooding to occur in a given year is predicted to be about 20 percent). Lowering the dam offers improvements in flood elevations:

1. Lowering the dam by one foot, lowers flood elevations by about one foot, sufficient to provide capacity for a 5-year flood event.

2. Lowering the dam by two feet, lowers flood elevations by about 1.7 to 1.8 feet just upstream of the dam. However, the 7-year event would still flow out of bank at the low point just upstream of the Escobar crossing.

3. Lowering the dam by 3 feet, provides greater than a 7-year storm capacity, with flood elevations within about 0.25 feet of design conditions.

These results were provided to the City preliminarily in December 2007. PWA recommended that if the City decided to maintain the beaver dam, it should be lowered by 2 to 3 feet from the October 2007 height. In January 2008, the City indicated that dam was lowered by about 2 feet from the October 2007 height and the flexible leveler was installed. The City indicates that the beaver dam height has remained relatively consistent.

Management Option #2 – Maintain Lower Dam and Excavate Expanded Floodplain

To help provide additional flow capacity to offset the capacity lost to the beaver dam, PWA suggested excavation of an expanded floodplain between the low flow channel and Castro Street as shown in Figure 8. This floodplain would provide extra cross-sectional area for flood waters to flow adjacent to the beaver

Plots comparing model results with the lowered beaver dam and expanded floodplain to the design channel with and without the lowered beaver dam are provided in Figures 10, 11, and 12 for the 2-, 5-, and 7-year flood events. For the 5- and 7-year events, predicted water levels for the lowered dam with an expanded floodplain are within about 0.1 foot of the design water levels immediately upstream of the dam and are virtually identical at the low point in the channel bank just upstream of Escobar Street. These model results indicate that the potential increases in flood risks associated with the beaver dam can be offset by excavating an expanded floodplain 2 to 3 feet below the October 2007 beaver dam crest.

Management Option #3 – Remove or Lower Dam in Response to Extreme Rainfall Event
In the event of an extreme storm that could result in a discharge greater than the 5-year flow prior to excavation of an expanded floodplain, the City may opt to remove or further lower the beaver dam to limit the potential for flooding in downtown Martinez. To help identify a threshold for management action during a major rainfall event, we obtained Contra Costa County rainfall records and identified key rainfall gages for the City to monitor during extreme rainfall events.

The Arroyo Del Hambre raingage (Station 37) is located in the headwaters of the Alhambra Creek watershed at Elevation 800'. This would provides the best indicator of flows in Alhambra Creek The Contra Costa County Flood Control District raingage (Station 11) is located in an adjacent watershed at Elevation 160 feet, and can provide a back up if the Arroyo Del Hambre gage fails.

When heavy rainfall is predicted for the East Bay including rainfall amounts greater than 2 inches in the next 24 hours and/or urban small stream advisories are issued by the National Weather Service, the City should monitor Contra Costa County's real time hydrology data web page:

http://www.co.contra-costa.ca.us/depart/pw/content/Hydrology.html#Antecedent

Since hydraulic modeling indicated that Alhambra Creek with the beaver dam lowered by about 2 feet has about a 5-year capacity, we identified 5-year rainfall depths as a threshold for potential high creek flows (and channel management activity). Key rainfall depths to monitor for to initiate management actions are presented below in Table 4.

- Dam debris may not readily move downstream, and could possibly cause some obstruction at the down stream culvert at Marina Vista or the railroad bridge and increasing flood risks at these locations.

Conclusions

Based on this analysis, we can draw the following conclusions:

1. The beaver dam continues have a significant impact on conveyance and water levels in the downtown reach of Alhambra Creek.

2. Hydraulic modeling indicates that the action taken by the City in January to lower the dam by about 2 feet below October 2007 height decreased the risks of a flood in downtown from about 1 in 4 (4-year event) to about 1 in 6 (6-year event).

3. Excavating an expanded floodplain adjacent to the lowered beaver dam could further increase conveyance and decrease flood risks to near pre-dam conditions (between an 8-year and 10-year event depending on tide levels). This approach is recommended to help offset the potential increased flood risks associated with the beaver dam.

4. Creating an overlook at Castro Street could provide public access for viewing the beaver dam.

5. Removal or further lowering of the beaver dam during an extreme flood event could further reduce flood hazards to downtown. However, site access and working conditions would likely be very difficult.

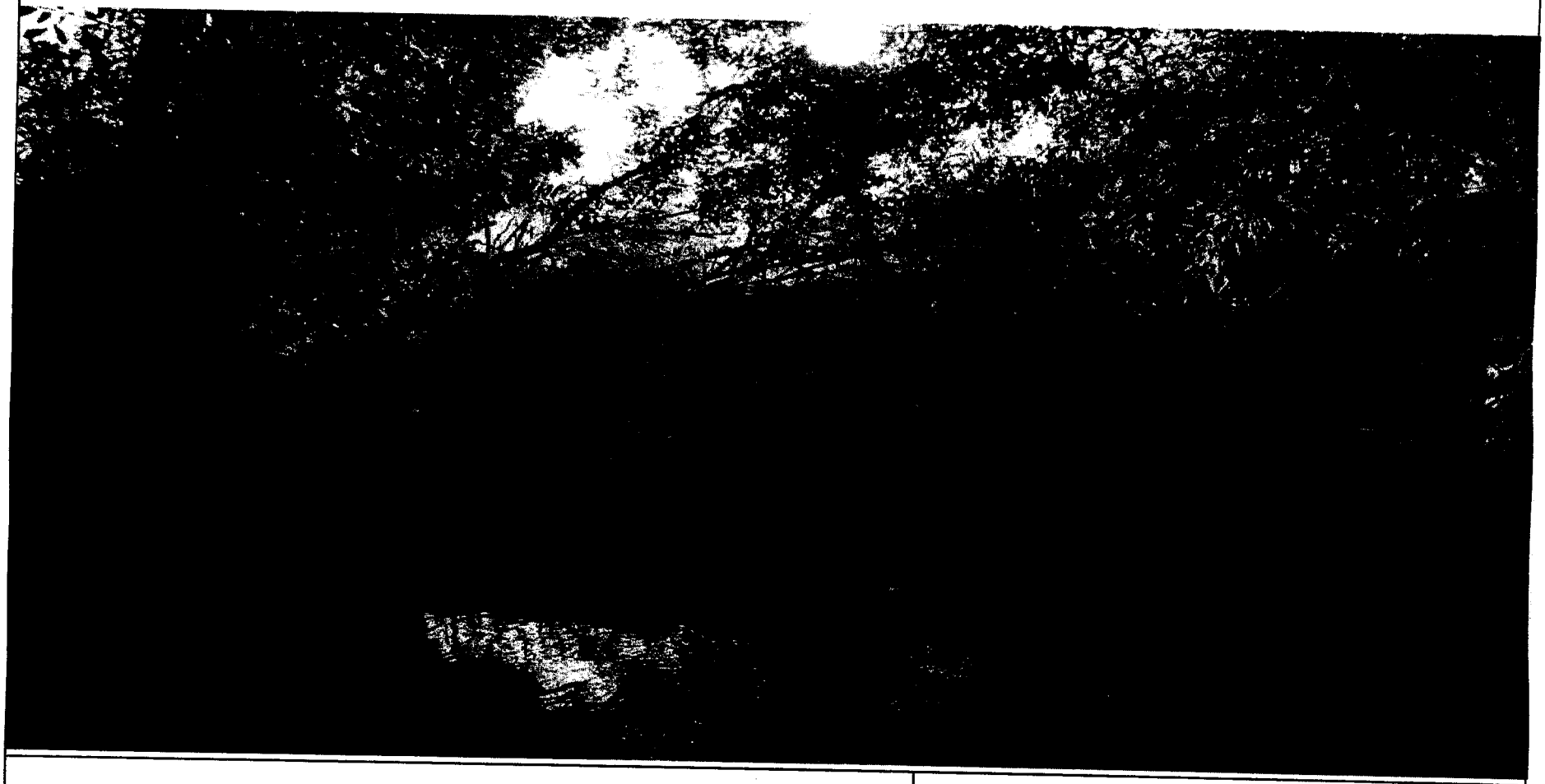

figure 2
Alhambra Creek Beaver Dam – Management Options

Beaver Dam in November 2007

PWA Ref# 1823.02

PWA

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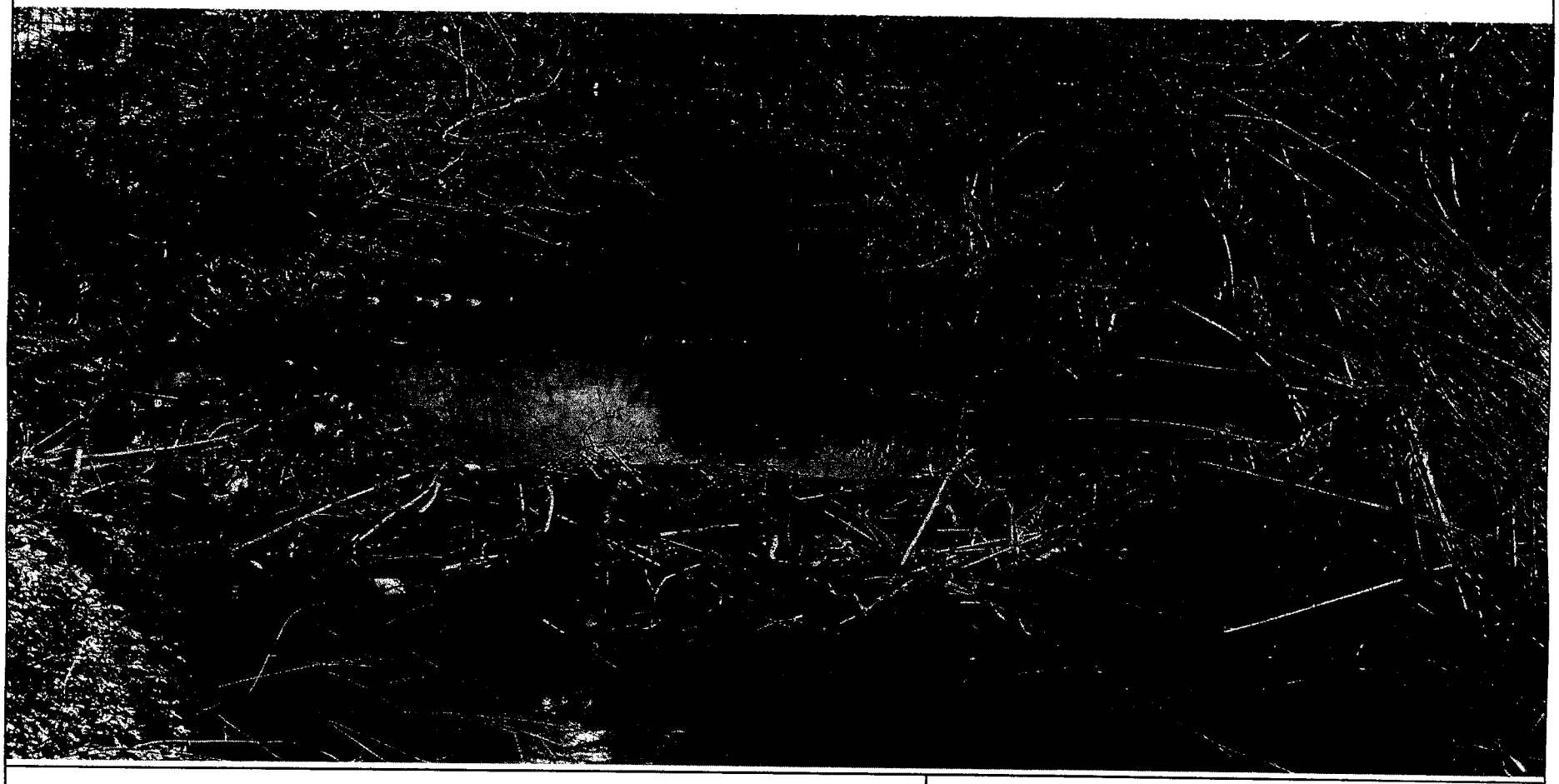

figure 4
Alhambra Creek Beaver Dam – Management Options

Lowered Beaver Dam with Beaver Deceiver

PWA Ref# 1823.02

PWA

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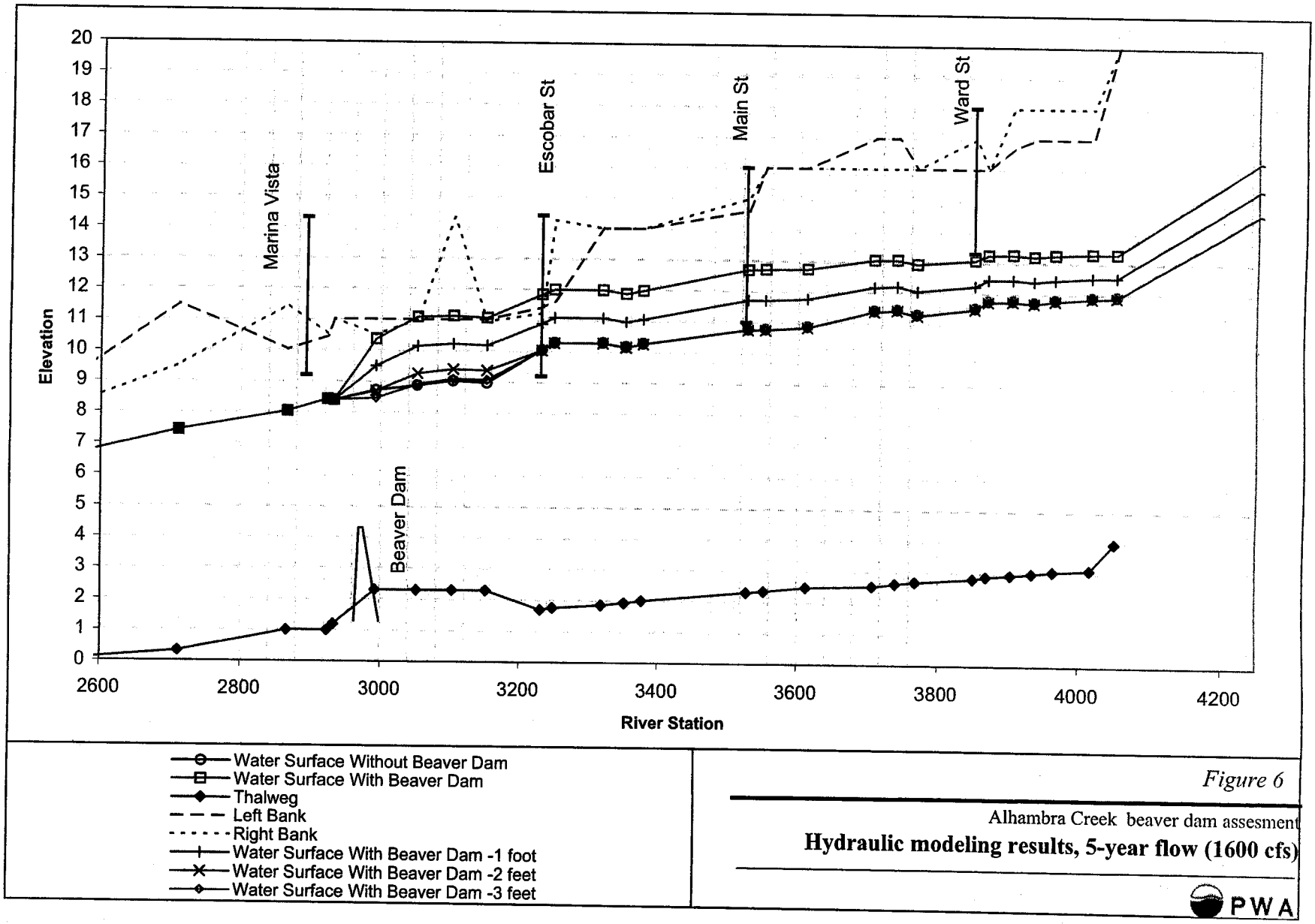


Figure 6

Alhambra Creek beaver dam assesment

Hydraulic modeling results, 5-year flow (1600 cfs)

PWA

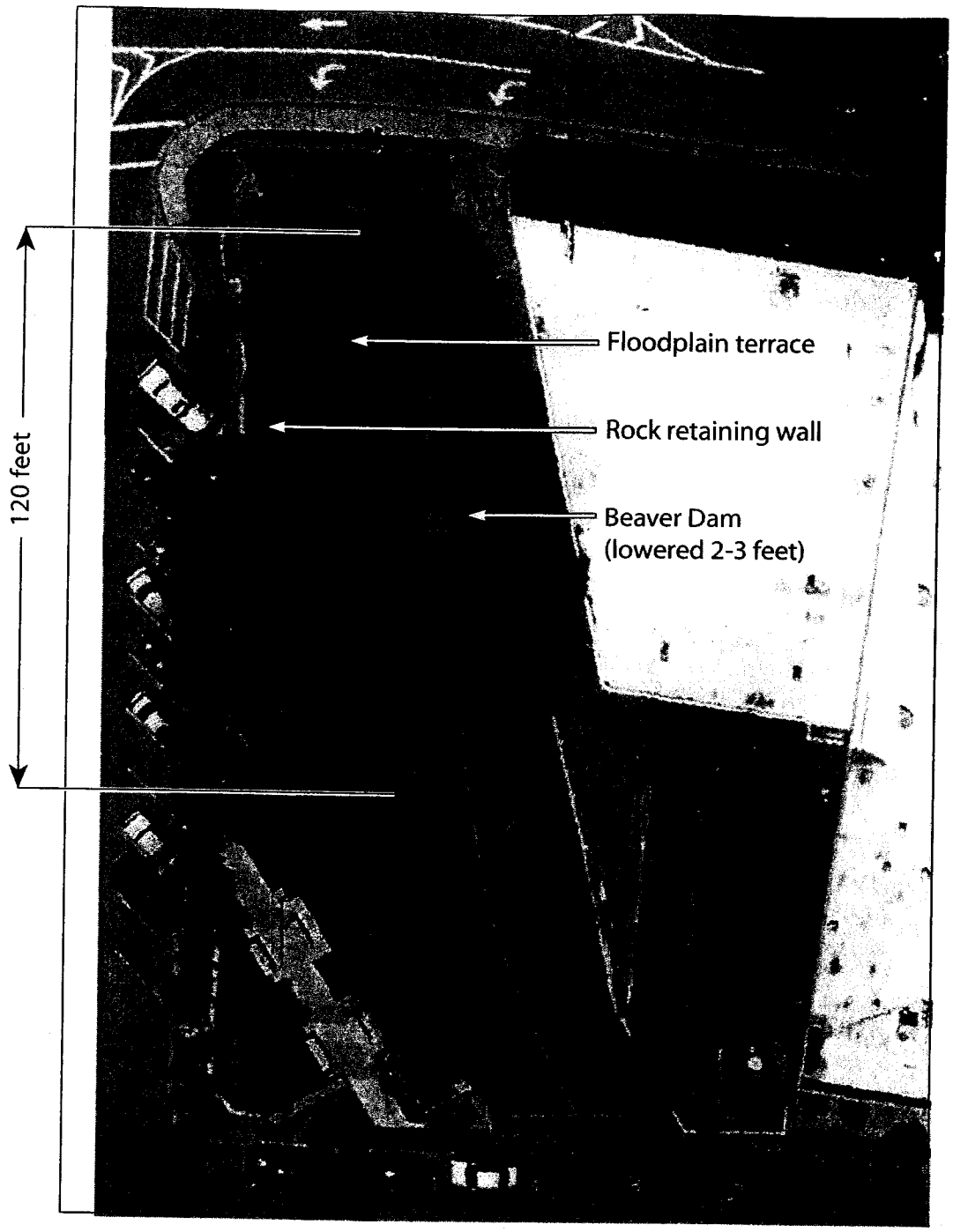


figure 8

Alhambra Creek Beaver Dam - Management Options

Plan View - Proposed Floodplain Expansion

#1823

PWA

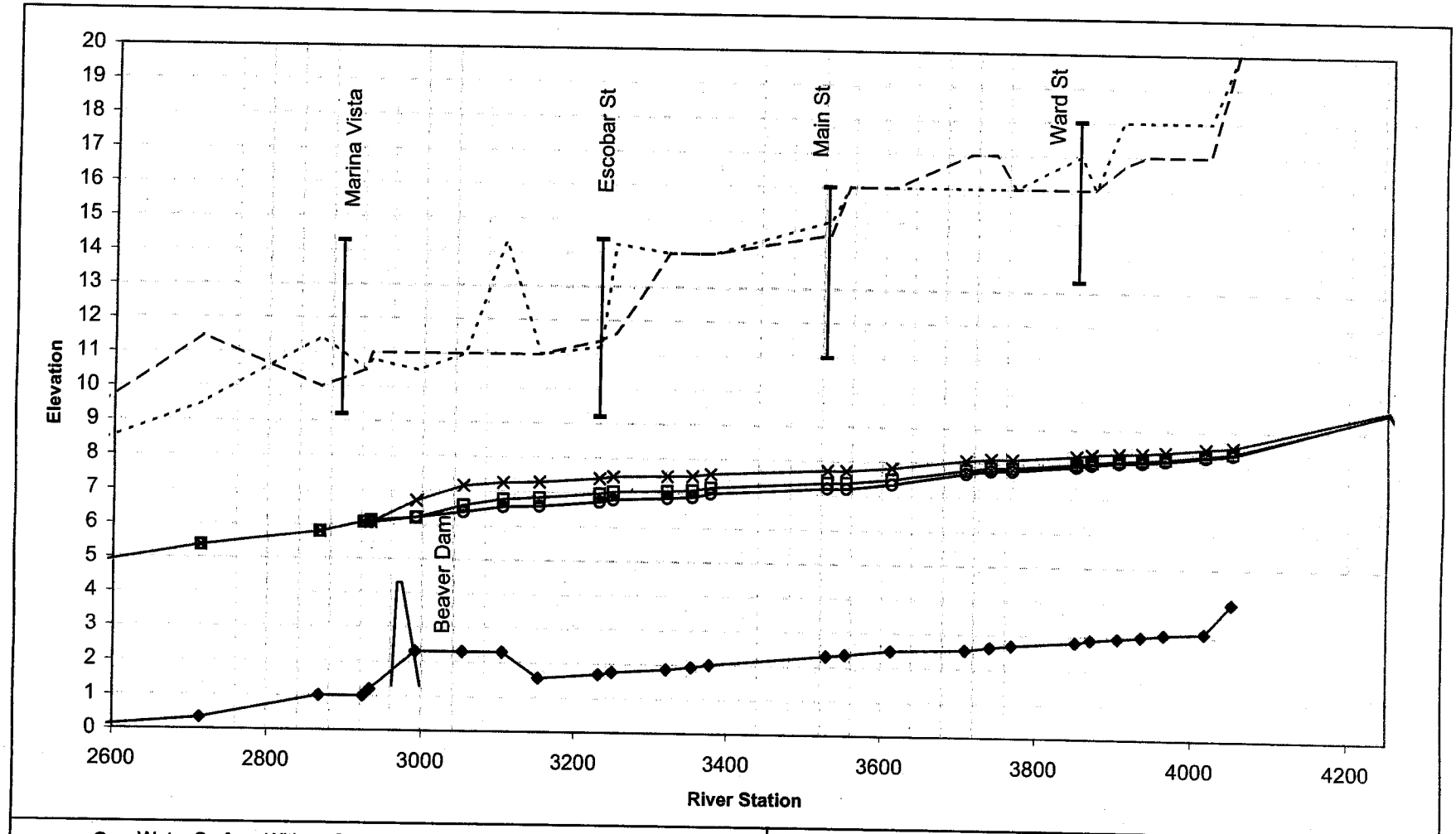


Figure 10

Alhambra Creek beaver dam assesment

Hydraulic modeling results, 2-year flow (634 cfs)

PWA

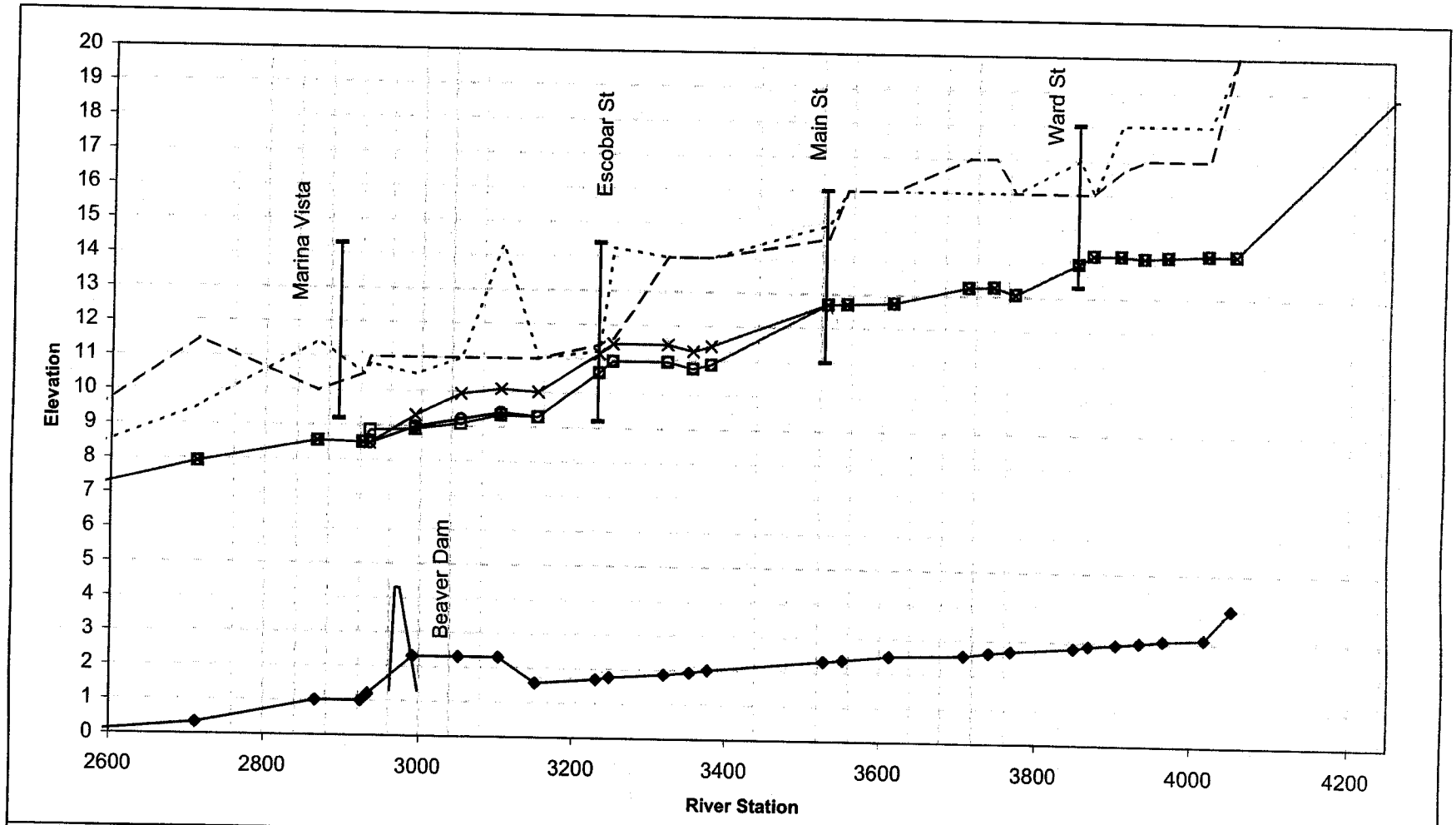


Figure 12

Alhambra Creek beaver dam assesment

Hydraulic modeling results,7-year flow (2000 cfs)

PWA

Beaver Dam Information Site

Photograph of a small beaver dam about 5' high, storing an estimated 50 acre feet of flow reserve on a trout stream tributary, near St. Paul Minnesota. Discharge stream below feeds into a trout stream. This dam is the second of a series of 3 similar raises within 200

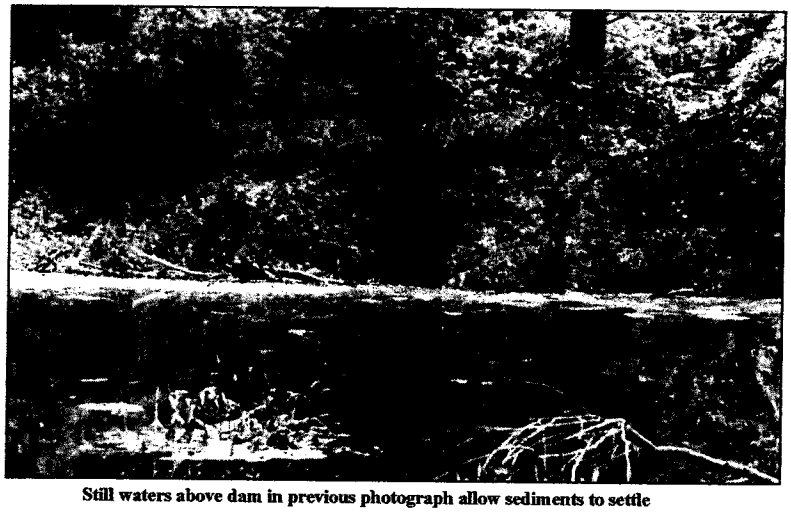
This site is dedicated to one of the primary keystone species, the beaver. A keystone species is one that modifies the natural environment in such a way that the overall ecosystem builds upon the change. The ponds, wetlands, and meadows formed by beaver dams increases bio-diversity and improves overall environmental quality. It is our opinion that many environmental decision makers do not fully understand the positive effects that beavers and dams bring to ecosystems. This is understandable, because beavers had been virtually eradicated prior to the development of modern scientific methods. This site incorporates first principle engineering concepts in combination with environmental observations to illustrate the extent that our watersheds have changed with the removal of beavers. Beavers affected our ecosystems and land in a very extensive and positive way. Modern society has recently begun to realize the benefits of wetlands. This realization marks a turning point in over 300 years of extensive wetland eradication. Beaver dams are the primary natural method of establishing wetlands. Beaver dams represent the only natural methods of forming lakes, ponds, and wetlands in most watersheds. The exceptions to this would be glacial lakes, or lakes formed by geologic activity. This website is designed to show the numerous benefits of beaver dams.

Benefits of Beaver Dams

- Nullifies "ditching effect" on water tables caused by deepening river and stream channels.
- Reduces channel scouring and stream bank erosion.
- Erosion mitigation.
- Reduction of sediment loading in streams and rivers.
- Development of new wetlands.
- Increased biodiversity including a better environment for fish and waterfowl.
- A more stable water supply for wildlife, and vegetation.
- Ground water recharge and ground water table elevation.
- More cold water springs charging rivers and lakes.
- Longer land water retention time in water cycle since subsurface flow is slower than stream and river flow.
- Flood mitigation due to increased ground water holding capacity. (More capacity then the ponds themselves!)
- Dampening of stream flow rate variations and stream charge during drought cycles.
- Formation of natural lakes and ponds, and maintenance of existing ponds.
- When dams ultimately silt in, natural fertile beaver meadows form

Illustration credit: Reston Association

- Stills and deepens waters, improves canoeing.



Still waters above dam in previous photograph allow sediments to settle

Causes of and Effects of Wetland Removal

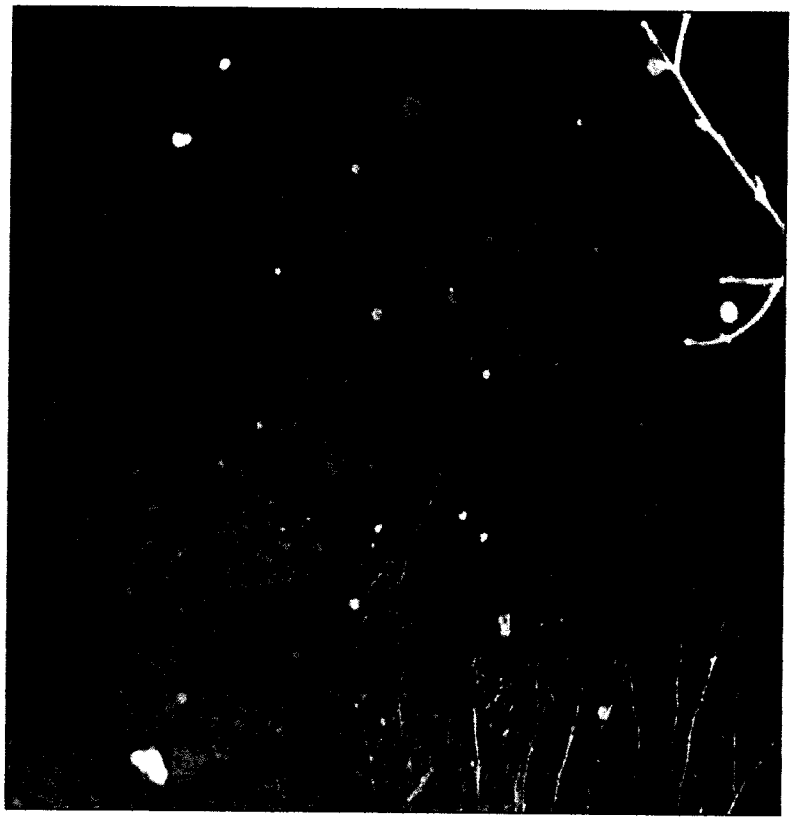
Most blame agricultural drainage and land development as the primary reasons for wetland loss. We do not think about the removal of beavers because we have no modern experience with this effect. Modern agricultural drainage may have less effect of wetland reduction, than the original removal of the beavers. Land drainage in the form of ditching and tiling is a relatively new phenomenon, so the cause and effect of changes can be better quantified. We can see a ditch, but cannot see the absence of a beaver dam. We know of no scientific articles that have actual hydrologic data describing the effects of removal of beaver dams on a large scale. A visualization experiment may be useful. What do you think removal of 250,000 water retention ponds and wetland areas ***per State*** in the Unites States would have on: 1) Flooding; 2) Groundwater recharge and quality; 3) Maintaining constancy of ground water tables and streams levels in periods of drought? Donald L. Hey has written an excellent scientific paper on this topic that was presented to the Annual Meeting of The American Institute of Hydrology 2001 titled, "Modern Drainage Design: the Pros, the Cons, and the Future." This paper states that watershed policies of agricultural and urban drainage have worsened flooding and drought effects. Our watershed management decisions must be made in the context of understanding the original extent of the effects of beaver dams. Of course, it would be impossible to restore all of the wetlands, but the benefits of wetlands should be considered when choices are available.

Stream Bank Erosion and Stream Sediment Loading

One specific example of the missed opportunity of beaver dams is in stream bank erosion and stream meandering. Numerous textbooks state that stream meandering is caused by physical processes seeking equilibrium energy dissipation rates. It is also taught

Unstable stream bank (white dots are blurred snowflakes).

that equilibrium will be achieved when the rate of streambed erosion equals the rate of deposition. Given that beaver dams dissipate flow energy, and change channels into stilling pools, why aren't there chapters on beaver dams in most geomorphology textbooks? Stream channels would be more stable as still interconnected ponds with energy dissipating steps. Currently, these eroding banks are far from achieving a state of "equilibrium" and will continue to scour both deeper and wider. One alternative method to stop stream bank erosion and meandering would be to restore beaver dams in these erosive meandering areas. The photograph to the right shows an unstable stream bank about 6 feet high. The width of the channel is 20 feet. Tree roots and vegetation are temporarily maintaining the unstable high angle of repose. This condition is not stable. The topography of the ravine in which this stream flows is a flat 200 yard wide meadow between steeper ravine side slopes. It is apparent that the stream channel is gouging deeper into the meadow. The sediments from the bank erosion will be washed downstream, ultimately into the Mississippi river. The depth of scour (unstable bank height) is the result of the change causing the instability. In most cases this will have been the removal of the original beaver dams. It is estimated that the beavers were originally removed from this area 150-250 years ago, and that the original dams deteriorated after this time. Beavers have recently returned to this area and have begun building numerous small dams, including the one in the picture (below) which is 150 yards downstream from this location.



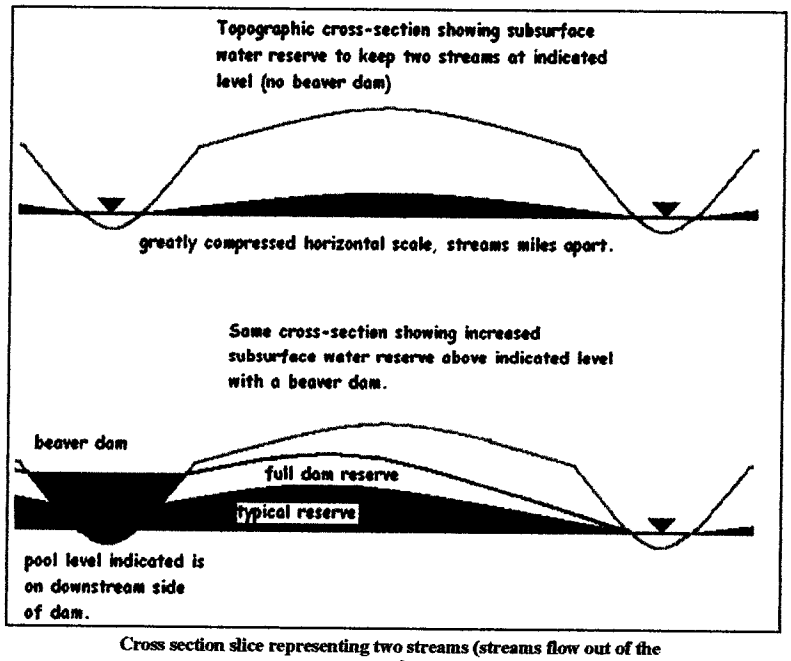
Newly started beaver dam downstream of eroding stream bank in previous picture
(White dots are blurred snowflakes)

The new beaver dam in the picture to the left is about 3 feet high. Repeating the previous paragraph the location of this dam is below the unstable stream bank area 150 yards upstream. This dam triples the upstream depth compared to the downstream depth. Any increase in width or depth of a stream channel (cross section area) will reduce the stream velocity in proportion to the increase in width times depth. Upstream of the dam, sediments are being trapped because of the reduced velocity. The upstream area will silt in and if the beavers are left undisturbed, the dam will continue to be raised until it actually tops the channel bank and will be built wider – beyond the scoured existing banks. The sediment stilling effect becomes more pronounced as the pond gets wider. Ultimately, all of the erosion potential of the previous photograph would be stopped. The meadow and wetland would be restored! Rather than having several hundred yards of eroding stream bank loading the stream with sediments, there will be a single dam slowing the water, stilling the sediments, and dissipating the erosive energy. A part of one the original ancient dams that

formed this meadow still exists in this area, it is 12 feet high with a base width of 30 feet. It is located at a point where the ravine width narrowed to about 100 yards.

Several questions in emails have been raised regarding habitat conflicts between beaver dams and fish. If the area depicted above this dam is restored to a wetland/meadow will it be suitable for the same types of fish? The answer is that our notions of natural stream channel profiles are incorrect. It is necessary to recognize the scouring/deepening channel in the stream bank photograph above as unnatural. If the ultimate outcome for the floor of this ravine area is a pond or wetland, there will be a change in the habitat. The pond will be suitable for some types of fish depending of the sediment, nutrient, and pesticide loading levels. The benefits of wetlands and meadows caused by beaver dams are typically seen downstream. Wetland buffers upstream of lakes, for example, improve lake water quality by reducing sediment and nutrient loading into the lake.

Beaver Dam Effects on Watershed Subsurface Water Reserve



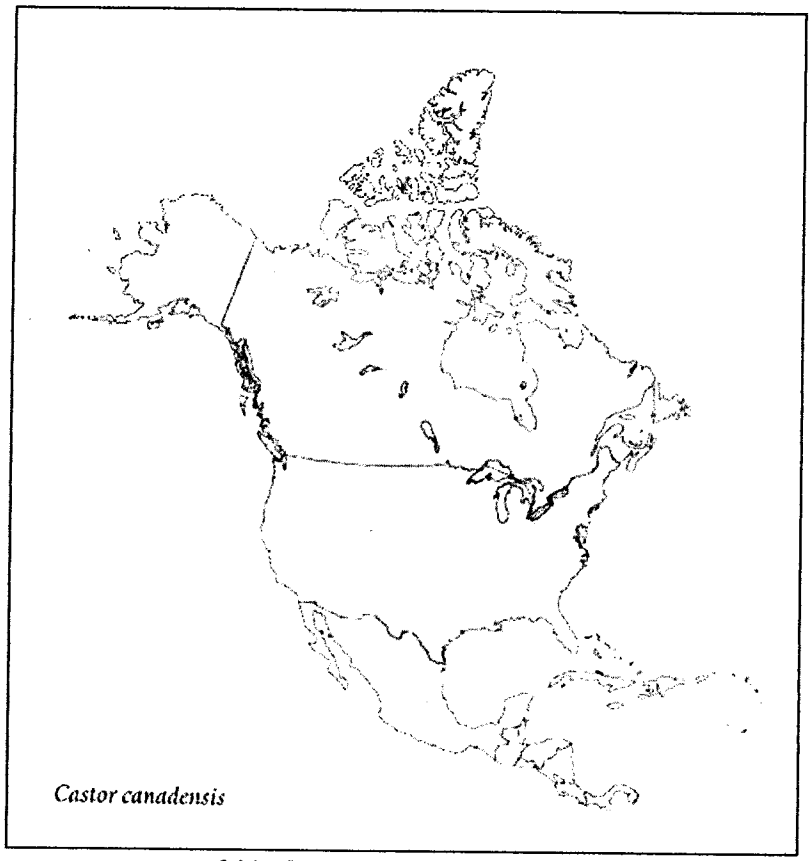
Cross section slice representing two streams (streams flow out of the page).
Blue ground water reserve keeps streams flowing until the reserve reaches

The illustration to the right depicts how beaver dams in stabilize stream flow rates. The illustration shows a horizontally compressed cross section between two streams, and how groundwater charge keeps the stream flowing. The river channels are the "U" shapes and the water flows towards you. Groundwater charge is the reason streams continue to flow without inputs such as rainfall. Water will continue to fill the stream until the level of the black triangles is reached. The top illustration shows the surface profile, and the groundwater levels for typical rainfall conditions with no beaver dam. The bottom illustration shows the elevation of the groundwater table under the same typical conditions with a beaver dam present. Beaver dams naturally leak, so the stream will continue to be fed until the level of the black arrows are reached. Notice that the "typical reserve" is greater in the bottom illustration, and that an additional storage buffer exists for wetter conditions. This wet condition buffer is represented by the white area "full dam reserve" and provides storage for flood mitigation. The blue area is the water charge, and the curved top is caused by rainfall. The effects of beaver dams in increasing the charge of aquifers reaches (sideways) across to the next watershed, and upstream as far as the pool is raised! The increased "typical reserve" behind a beaver dam is of significant benefit to wildlife and fish during periods of drought. The benefits are also seen downstream since beaver dams inherently leak as do charged aquifers. Water springs are the result of water flowing out of charged aquifers. These springs can occur above and below the stream surface. They tend to be moderate in temperature at the average seasonal

temperature.

**Cold water spring in proximity to beaver dams.
These springs also occur in streams but cannot be seen!**

North American Beaver Range

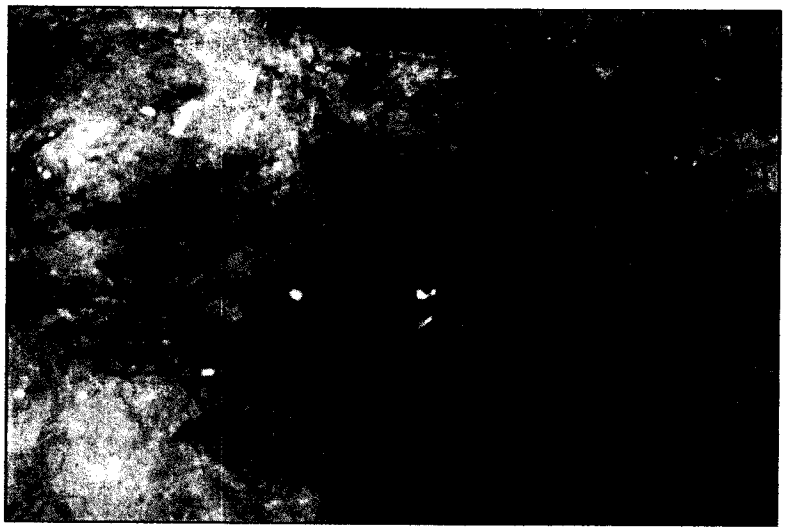


Original North American Beaver Range Map

Beavers covered most of North America prior to 1700. It is estimated that over 60 to 200 million beavers populated the range shown on the map. The beaver's influence touched every watershed in North America. Assuming 100 million beavers in the United States and 8 beavers per dam, there may have been an average of 250,000 ponds per state! Beaver dams significantly influenced erosion/deposition patterns over the entire country. The sediments that were dislodged from the naturally vegetative covered land were often recaptured in the natural stilling ponds created by beaver dams. Water after passing through beaver ponds and wetlands was of better quality with reduced sediment load. The natural energy dissipative characteristics of the spill side of these dams further reduced the erosive potential of flowing streams. Erosive energy was dissipated in the seepage through, and over the beaver dam.

In the 1805 Lewis and Clark expedition up the Missouri River, beavers were observed wherever the habitat was suitable for them (EPA News-Notes). The water transportation systems of the Native Americans also must have been assisted by the numerous beaver dams. The elevated water tables also improved the vegetative ecosystem.

Beaver Dams and Fish



Trout in stream below dam in first picture

Beaver dams pose no unnatural hindrance to fish and may actually beneficial to such native cold water fish as trout. Beaver dams were the norm prior to 1700 in North America, fish and beavers had to have evolved together (reference above 250,000 dams per state)! The height of beaver dams is typically less than 10 feet. Fish migrations are seasonal, and typically occur in the springtime. In the spring high flows often overtop dams, and the downstream water level approaches that of the upstream side of the dam. The fish that evolved under pristine conditions in North America can easily swim over dams in these conditions. These flow conditions in the northern latitudes usually occurred in the spring when the water was colder. This presents a clear advantage to trout and similar native species over warm water species such as carp (non native). The temperature of the water charge during low flow periods will be cooler given the fact that low flows in rivers are the result of groundwater flow. In most climates low flows (droughts) occur during the summer season. Groundwater most always recharges rivers and streams during droughts at the average seasonal temperature. Trout seek these cool spring fed areas during the warmer weather. In some cases, as previously discussed, beaver dams will form wetlands and meadows, in this case the benefits to fish are seen downstream of the dams, with improved water quality in downstream lakes and streams.

Landscape Differences with Beaver Dams

Geomorphology is the study of changes of the earth's surface over time. A number of plants and animals have a significant effect on the type of changes that will occur. Prairie dogs, for example, reverse soil compaction improving permeability and rooting conditions for plants. Earthworms significantly affect the ability of the soil to absorb water during a rainfall event. Trees, grasses and

other vegetation stabilize soil. Tall prairie grass in particular tends to enable the filling in of "micro gullies" that if unchecked would become larger gullies. This grass "lies down" during overland flow, protecting the soil, and allowing sediments to fill in small erosive starts. Beavers work on a macro scale creating ponds that support other life forms including fish and waterfowl. The natural sedimentation in beaver stilling ponds reduces downstream sedimentation, and ultimately forms flat fertile wetland and grassy areas called "Vegas". The term Vega is Spanish for fertile valley, and refers specifically to a silted in dam or natural beaver meadow. UNM Sevilleta LTER Vegas occurred more commonly in mountain areas where erosion rates were naturally higher. Ranches, farms and cities were built on these natural flat fertile areas. Beavers had to be reintroduced in some of these Vega areas to stop the erosive processes that greatly accelerated after the beavers were removed.

The natural geomorphologic outcome for continents without beaver dams will include more ravines and steep valleys, due to the cutting erosive forces of flowing water. As inland river channels deepen, streams that flow into the main river will form. These streams concentrate the precipitation flow, which increases the scouring (deepening) of the river channel. This deepening effect amplifies itself. This is the reason that rivers form. The deeper channels increase erosion rates, leading to distinctive ravine topography. The ultimate result of this system will be low and flat topography, with the finer sediments washed into deltas. Beavers instinctively build dams in areas of more rapidly moving water, which reduces scouring – reducing channel deepening. Beaver dams typically bring the water surface to the top of the riverbank. The sediment deposition in beaver ponds also counteracts scouring (channel deepening). Prior to 1700 many streams and rivers may have been actually a series of ponds with steps (dams) between them. Early geologists observed this step topography. A very large number of beaver dams will shift precipitation flow from rivers and streams into more overland flow, and underground flow towards the ocean. Overland flow and underground flow are slower than stream flow (for equivalent rates), which reduces peak flow rates in rivers after a precipitation event. Reduction of peak flows reduces flooding and erosion. Underground flow certainly resulted in no surface erosion.

Erosion in itself is a natural process; there will ultimately be equilibrium between fine soil formation and erosion. Under natural "pristine" conditions with beaver dams the amount of fine sediments present on the land at any time was significantly higher than with current agricultural and development land use patterns. The greater amount of fine sediments contributed to greater fertility and biodiversity. Agriculture and land development currently play the major role reducing soil equilibrium amounts. The textbooks referred to this change in equilibrium as the land "wearing out". Actually, loss of fertility may have been the result of the loss of the very fine sediments that had been captured in grasslands for eons. Current land use has so radically increased erosion that dammed ponds totally silt in a period of a few years. Research needs to be done to determine the optimal balance between wetlands and agriculture. Progressive thinking may show that sustainable agricultural production and environmentally sensitive land management practices can be achieved with the same land usage practices. The current understanding of the benefits of wetlands and the basic concepts reviewed here should cause us to seriously reconsider the positive effects of beaver dams on ecosystems.

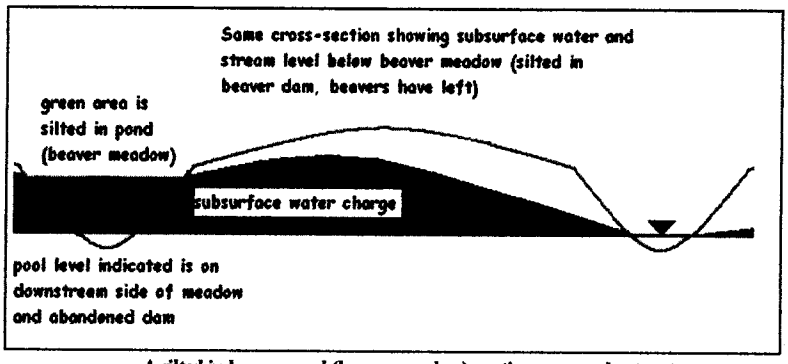
Conflicts with Beavers

There was an inherent conflict between early agriculture and beavers. The fertile land flooded by beaver dams was prime farmland. The beaver fashion hat industry may have developed as a by-product of the early efforts to clear agricultural land in Europe. Most of the early the fur trade, led initially by the French voyagers, the North West Company, and the British Hudson's Bay Company, drove settlement of North America. The beaver pelt was one of the most valuable furs, leading to virtual extinction of beavers in the early 1900's. From a historical perspective it is interesting to note that the greatest harvest rates of beaver pelts in the Lake Superior region occurred prior to the signing of the United States Declaration of Independence. The few beavers that were left when land was homesteaded were likely removed since they were a hindrance to farming. Later government agricultural drainage programs went even further to reduce wetlands. Modern agricultural drainage programs may have had less effect on wetland reduction than the earlier removal of the beavers.

Another current area of conflict with beavers is that they tend to preferentially built dams that interfere with road crossings over flowing water: they especially tend to plug up culverts (if you have an original picture of this send it and we will post it with an illustration credit). The reason for this is that the designs for road crossings tend to constrict the flow which speeds up the water, and tends to

make riffling sounds. The sounds of flowing water in addition to a velocity threshold compel beavers to build dams. Clemson University has developed a correction for this problem with the "Clemson Pond Leveler." This device is designed to quiet the sound of water and to reduce the directional velocity. A long term approach to this problem is to "just stop" constricting streams. Multiple box culverts and bridges are less constricting than single round culverts. Streams should be wider, deeper, and slower at road crossings. Our highway and waterway engineers need to be taught that constricting streams will inevitably lead to beaver problems (and associated costs). The potential for Beaver dam problems should be considered in all water project environmental impact statements and benefit cost analysis. It may be cheaper to just kill beavers, but it is more socially appealing to reduce the potential for beaver problems in the design phase of highway projects.

Benefits of Beaver Meadows



A silted in beaver pond (beaver meadow) continues groundwater storage benefits.
As with a beaver dam the stream below the meadow will continue to be fed with cool ground water.

There is currently a debate going on over what to do with silted in ponds. The two sides of the debate seem to be to either remove the dam and restore the river to an "unobstructed" state or to dredge the sediments out of the pond. It is unfortunate that the ponds have sedimented in so quickly! Total removal of the dam would result in the captured sediments being washed away resulting in years of very high sediment loading downstream. Removing the excess sediment would be expensive, since the pond will just silt back in. Erosion preventative land use practices and upstream stilling sediment catch basins may be a partial solution. The natural model would give some insights. In some cases the beavers continued to raise the pool level, in other cases they would leave and build upstream or downstream. The high sediment loading rates add a complex dimension to this problem. Even so, environmental decision makers must realize that the flat beaver meadow areas left after pools silt in are natural phenomena and these may provide excellent park and recreation opportunities. The stream will flow through the beaver meadow, but the dam forms a natural energy dissipating drop structure. This grassy meadow will flood during high flows, and will continue to capture sediments. The elevated water table caused by the meadow will still contribute to charging the lower stream during periods of drought. The full subsurface reserve would still exist and the silted in pond volume will now be part of the subsurface reserve. The exact hydrology of this system varies, but beaver dams and meadows always increase the subsurface water charge. This concept is shown in the illustration to the right.

Pond above a mature beaver dam,

The following links substantiate the ideas presented on this page. If you want your page linked here please write!

UNM Sevilleta LTER
Mass. Soc. Prev. of Cruelty to Animals
Beavers - Wetlands and Wildlife
Outwater
Cuyahoga Valley National Park
Agency
University of Georgia
abob, University of Georgia
Beaver Dams by Bob Arnebeck
Initiative
Clemson University
Mills 1909
Science Daily

White Oak Society
TreesForLife -United Kingdom
Nature's Hydrologists by A.

U. S. Environmental Protection

Reston Association
Hinterland Who's Who
The Wetlands

The Beaver and his Works,

Livescience Animal Domain

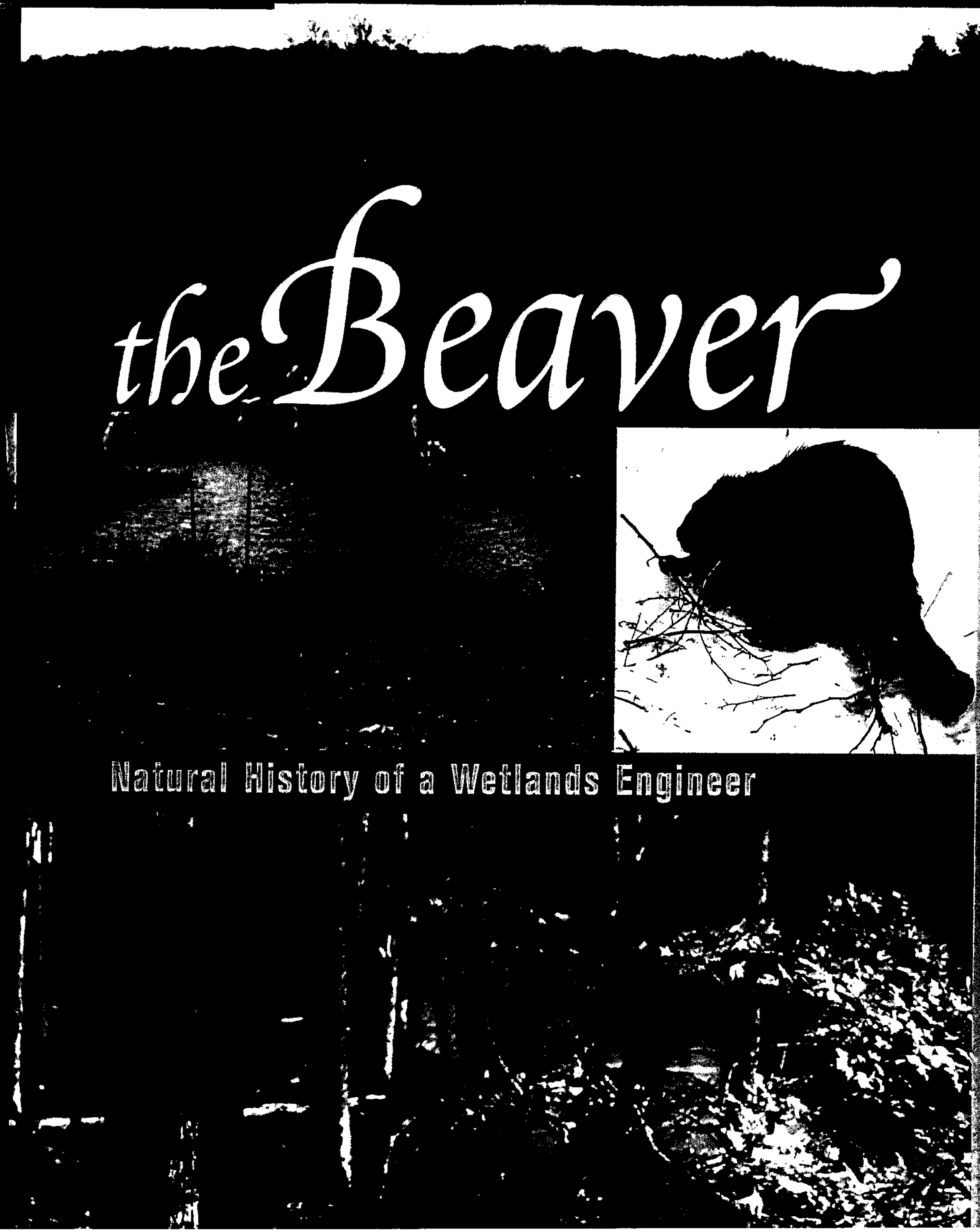
This site is updated frequently. If you have any suggestions, comments, or would want a link to your environmental site please write:
mailto:editor@beaverdam.info?subject=Comment on Beaver Dam Site

The ideas on this page originated from coursework in the Agricultural Engineering Department at the University of Minnesota. The author, Steven G. Grannes has a Master's Degree in Agricultural Engineering with an emphasis in Soil and Water Management.

Last Updated: 29 June 2007

Beaver Dams

Wash out!



However, beavers do not depend only on what is naturally available to them. They enjoy a unique ability to actively modify the landscape to create a habitat better suited for their needs.[10] At Allegany State Park, beavers living in Red House Creek often suffer from inundation during the summer, when sudden thunderstorms or torrential rains flood the land. Although beaver dams are engineering marvels that last several years by virtue of maintenance and continuous strengthening, many dams still become seriously damaged or totally washed out. In 1 year we lost two-thirds of 20 study colonies this way. The ponds drained completely. After the flood, the beavers came back to reclaim their home and quickly rebuilt all structures, including the damaged lodge and dams. Really successful beavers prevent such catastrophes by building a small pond off the main course of a stream, branching off only some water, like the millrace of old. This "design" has a disadvantage: at low stream levels, fresh inflow may stop, and the water in the pond becomes stagnant or even dries out intermittently.

Developed Landscape

As beaver populations grow, they recolonize former beaver habitat that is now occupied or used by humans. In North America, beavers move into suburbs, golf courses, even shopping centers, leading to conflicts with people, as we discuss in detail in chapter 19. Such encounters with the developed landscape are the norm in Europe. In Bavaria, beavers settle along ditches with only narrow strips of woody vegetation that separate the watercourse from agricultural fields. The animals adapt to the scarcity of trees by utilizing a long stretch of the ditch or stream. In summer, six measured home ranges ranged from 1770 to 3270 linear meters, while those distances shrank to 300–820 m in winter.[11] Flexible as beavers are, they compensate for a lack of natural vegetation by foraging in agricultural fields. Among the 300 documented plant species eaten, they consume corn (maize), other grains, and sugar beets.[11] Plate 34 shows a bank lodge at a backwater in the floodplain of the River Elbe in central Germany. Note the narrow strip of trees between the watercourse and the pastures and fields beyond. In keeping with the flexibility of the Eurasian beaver, human activity in the highly developed Rhone Valley in France did not seem to keep beavers from an otherwise suitable habitat.[4] As another example, beavers in the Czech Republic coexist with human use of their habitat (V. Kostkan, personal communication, 2000). In Slovakia, beavers immigrated from Austria. They even have taken up residence in Greater Bratislava, the country's capital, although two-thirds of the animals stayed at their sites for only 1 or 2 years.[12]

In summary then, both beaver species prefer habitats that provide a secure water supply and choice plants. But they manage to adapt to a variety of landscapes, even those permanently and thoroughly modified by humans.

The Beaver (Castor canadensis)

Beavers are more than intriguing animals with flat tails and lustrous fur. American Indians called the beaver the "sacred center" of the land because this species creates rich habitats for other mammals, fish, turtles, frogs, birds and ducks. Since beavers prefer to dam streams in shallow valleys, much of the flooded area becomes wetlands. Such wetlands are cradles of life with biodiversity that can rival tropical rain forests. Almost half of endangered and threatened species in North America rely upon wetlands.

Besides being a keystone species, beavers reliably and economically maintain wetlands that can sponge up floodwaters (the several dams built by each colony also slows the flow of floodwaters), prevent erosion, raise the water table and act as the "earth's kidneys" to purify water. The latter occurs because several feet of silt collect upstream of older beaver dams, and toxics, such as pesticides, are broken down in the wetlands that beavers create. Thus, water downstream of dams is cleaner and requires less treatment.

A Bit About Beavers

Beavers' ability to change the landscape is second only to humans. But that is just one reason why we find the flat-tailed species fascinating. Adults may weigh over 40 pounds, and beavers mate for life during their third year. Both parents care for the kits (usually one to four) that are born in the spring. The young normally stay with their parents for two years, and yearlings act as babysitters for the new litter. While some beaver behavior is instinctive, they also learn by imitation and from experience. Dr. Donald Griffin, the father of animal cognition, has said, "When we think of the kinds of animal behavior that suggest conscious thinking, the beaver comes naturally to mind."

Wildlife rehabilitators find beavers to be gentle, reasoning beings who enjoy playing practical jokes. An Indian word for "beaver-like" also means "affable." Once weaned, their favorite foods include water lily tubers, clover, apples and the leaves and green bark (cambium) from aspen and other fast-growing trees. Tree cutting is part of nature's cycle, and beaver pruning stimulates willows, cottonwood and aspen to regrow bushier than ever next spring. After eating, beavers use the peeled sticks to build a teepee-like lodge (house) on the shore and/or a dam.

By damming streams, beavers often raise the water level to surround their lodge with a protective moat, and create the deep water needed for winter food storage in northern climes. While other wildlife endure wintertime cold and hunger, beavers stay warm in their lodges with an underwater food cache of branches nearby. A beaver colony, can consist of six or more, including parents, yearlings and kits, yet they peacefully coexist in a lodge with underwater access to the iced-up pond for four months or more in the North.

Population

Because they breed only once a year, ~~require streamside habitats~~, and two-year-olds leave home each spring to find their own territories, beavers rarely overpopulate. They are limited to a small fraction of the landscape that is close to waterways. Kits have many predators including hawks, owls and otters. Bears, wolves, dogs and coyotes can also take adults that are especially vulnerable each spring when two-year-olds seek new territories. Accidents are another frequent cause of mortality, including falls into abandoned wells, and traffic accidents. Trapping is the most common source of mortality.

Like many wildlife species, beavers self-regulate by starting to decrease their rate of reproduction when occupancy reaches a certain level. In vast areas without trapping, beaver populations may peak, and then slowly drift down to a sustainable level. By the early 1900s, beavers were almost extirpated from North America due to trapping and draining of lands for agriculture. Estimates of the current population are as low as five percent of those present prior to European settlement. Nonetheless, as beaver reclaim some former territory, conflicts with humans arise.

At a German website about European beaver, you can order the Proceedings of the 2nd European Beaver Symposium (2000) in English. For information about the European Beaver, Castor fiber, and how Scotland is planning to reintroduce beavers, go to www.scotsbeavers.org.

Baffled by Beavers?

When conflicts arise, working with the beaver is most often the best solution. If beavers are removed from good habitat, others will normally move into the empty habitat. Survivors respond with compensatory reproduction and beavers can migrate over tens of miles. Allowing the beavers to remain while addressing the specific problem (for example, flooded roads or tree cutting), also preserves the many beaver benefits. Wetlands are decreasing worldwide, and certain programs, such as the U.S. Wetland Reserve Program, recognize the great environmental value of these vital areas by reimbursing landowners who protect wetlands. The U.S. Fish and Wildlife Service has the Partners for Wildlife program that can provide funding, or materials, for flow devices to qualified agencies or organizations. Freshwater wetlands have been rated in a study by over a dozen ecologists and economists as the world's most valuable terrestrial ecosystem in terms of natural services. By installing flow devices, often most of the beaver wetlands can be saved, while ending the unwanted flooding. Problems with objectionable tree cutting can often be solved with fencing or other methods (see "How to Protect Trees").

Proven, cost-effective devices, such as beaver pipes in dams, are installed to control objectionable flooding. Road flooding is a common beaver/human conflict that be solved with methods such as "exclosures," Beaver Bafflers" or Beaver Deceivers. Since beavers are quite adaptible, it is best to use **proven techniques.**

If beavers must be relocated, using Hancock or Bailey live traps are the most humane methods. Snares

hold the victim helpless against predators and can cause death by strangulation, or drowning due to entangement. No kill trap that currently exists will reliably cause an instant death under field conditions, and drowning traps are especially inhumane for animals that can hold their breath for 10 to 15 minutes. Like other wild species, surviving beavers respond to persecution with larger litters. Besides being a temporary solution, removal is often environmentally disruptive as it leads to the draining of beaver wetlands when beavers are no longer present to repair dams.

.Return to Home Page

Back to About BWW

RESOLUTION NO. 160-92

AMENDING THE GENERAL PLAN OPEN SPACE/CONSERVATION ELEMENT
BY ADDING THE ALHAMBRA CREEK ENHANCEMENT PLAN

WHEREAS, the City Council formed and appointed the Alhambra Creek Steering Committee and the Alhambra Creek Advisory Committee to review reports and provide feedback and information to the staff and consultant to assist in the preparation of the Alhambra Creek Enhancement Plan; and

WHEREAS, the Council recognizes and appreciates the efforts of the Alhambra Creek Steering Committee and Advisory Committee in the preparation of the Plan; and

WHEREAS, the Planning Commission, after a duly noticed public hearing on September 22, 1992, recommended by a unanimous vote that the City Council adopt a General Plan amendment adopting the Alhambra Creek Enhancement Plan as an amendment to the General Plan; and

WHEREAS, the City Council held a duly noticed public hearing on October 26, 1992, on the proposed General Plan Amendment to adopt the Alhambra Creek Enhancement Plan at which all interested parties were given the opportunity to speak.

NOW THEREFORE BE IT RESOLVED by the City Council of the City of Martinez that:

1. The Negative Declaration is hereby adopted as recommended by the Planning Commission.

2. The General Plan is amended as shown in Exhibit A attached.

3. That the remainder of the Alhambra Creek Enhancement Plan is adopted as a guideline for implementation of the goals and objectives identified in the General Plan Amendment.

4. That the Alhambra Creek Steering Committee and Advisory Committee be hereby dissolved and future efforts to implement the plan be conducted by the Leisure and Community Service Department in conjunction with the Commmunity Development Department and Public Services Department and volunteer citizen organizations such as the Friends of Alhambra Creek.

* * * * * * *

I HEREBY CERTIFY that the foregoing is a true and correct copy of a resolution duly adopted by the City Council of the City of Martinez at an Adjourned Regular Meeting of said Council held on the 26th day of October, 1992, by the following vote:

AYES: Councilmembers Farley, McDowell, Woodburn, Vice Mayor Smith and Mayor Menesini

NOES: None

ABSENT: None

GUS S. KRAMER, City Clerk

By: _____
Sherry M. Kelly, Deputy City Clerk

INTEGRATED GREENWAY PLAN

The Draft Enhancement Plan reflects an integrated approach to the design of a creekside greenway. The trails, habitat enhancements and bank stabilization designs proposed have been developed together so that each individual element supports the other. The greenway will unite the city with its creek and reestablish a natural, self-sustaining landscape. A continuous trail system will connect the neighborhoods with downtown, schools, parks and with the regional recreational trail network. People will be encouraged to walk or bicycle in safety to the downtown, with opportunities to stop and enjoy the restored natural setting. Educational exhibits will be available to describe the natural processes of the creek, its historic importance and the process of habitat restoration and bank stabilization. The improved habitat will bring a rich biological diversity into the center of Martinez. Stabilization treatments for the channel, its banks and the adjacent properties will work in concert with habitat restoration and will accomodate trail construction.

GOALS AND OBJECTIVES

The City of Martinez has gathered the community, consultants and staff to create a vision for the creek. One of the first steps was to develop the goals and objectives to guide the process of creating this vision. The goals and objectives were developed from the record of citizen input on past and current creek planning, from consultation with the City staff, and after a thorough analysis of the existing conditions within the study area.

The goals and objectives provide a summary of the desires of the community and the recommendations of the consultants with regard to enhancement of Alhambra Creek. Each goal has been listed here accompanied by related objectives and a discussion of the way in which the Enhancement Plan responds to that goal.

Goal 1: Create a **greenway corridor** along Alhambra Creek which **balances the community desires for public access, natural area restoration, wildlife habitat value enhancement, flood protection and bank stabilization.**

Objectives:

- develop a planting program along the riparian corridor that will support wildlife and fish habitat restoration.

- develop a tree planting program consistent with the riparian corridor planting for streets and other open spaces adjacent to the creek, to visually enhance the spaces, provide shade and widen the riparian corridor.

- limit and control public access in sensitive wildlife habitat areas
- Provide natural and artificial barriers to habitat impacts in high public use areas

Alhambra Creek is a prime candidate for creation of a restored greenway corridor in the one mile stretch of the study area. Restoration and wildlife value enhancement can be achieved with some modification of the creek banks, removal of invasive exotic vegetation, and revegetation with native plants. Public access has been carefully integrated with the goals of bank stabilization, revegetation and wildlife protection. Where the disturbance to wildlife would be excessive, public access is restricted or curtailed. A continuum of natural and urban experiences is provided within the greenway corridor.

Goal 2: Create an access and enhancement plan which maintains the **privacy and security** of creekside properties and residents and the **safety of those using the creek**.

Objectives:

- Develop a public access system which is easily monitored for the safety of the users.
- Develop a public access system which encourages active use by residents and visitors, and minimal conflict with property owners.
- Develop measures to secure the safety and privacy of residents, students and property owners where a public trail or overlook occurs near a residence or school.

To protect the privacy and security of property owners, access to the banktop is primarily restricted to existing public property. The few parcels where access is recommended on private property occur mainly in the downtown area where owners may benefit commercially from the presence of trail users or an enhanced creek environment.

Providing for the safety of those visiting the creek is an important security concern. The recommended trail system can be monitored from public streets or populated areas.

Goal 3: Improve the **habitat values for wildlife** in the riparian corridor and for fish in the creek.

Objectives:

- Preserve the existing healthy riparian habitat.

- Establish an overall vegetation management plan that supports the habitat restoration, bank stabilization, flood capacity, and aesthetic enhancement goals.

- Enhance and restore fish habitat values in the creek.

- Widen the riparian and marsh zones beyond the narrow channel corridor wherever possible, creating buffer/transition zones between the creek and urban areas.

- Buffer fish and wildlife habitat from public use and other urban adverse impacts.

- Create guidelines for consistent bank stabilization treatments for public and private land along Alhambra Creek. Treatments should improve habitat values and aesthetic quality of the creek.

- Improve water quality, minimize water quality hazards and protect public safety.

The riparian corridor is currently quite narrow and isolated from surrounding habitats. Improving habitat values for fish and wildlife can be accomplished primarily by reestablishing and expanding the layered vegetation canopy of the riparian corridor. This revegetation provides habitat for animals, with a variety of native plants offering shelter and food. In addition, trees will provide a dense canopy over the creek, shading it and reducing water temperatures for fish. In many stretches of the creek, where natural banks have been stabilized with manmade structures and the vegetation removed, alternative means of bank stabilization which include revegetation and wildlife enhancement are recommended. Hazardous waste sites which could potentially leak into the creek, affecting water quality and public safety have been identified in the Plan. In the downstream reaches, alternative means of expanding the wetland habitats are explored.

Goal 4: Create an access and enhancement plan that **maintains or improves**, where possible, the **existing level of flood protection** along the creek.

Objectives:

- Conduct a detailed hydraulic study of the project area to ensure that the treatments recommended as part of this Enhancement Plan do not alter existing flood levels.

- Develop a monitoring and maintenance program of the enhancement work for Alhambra Creek for debris and silt build-up and invasive vegetation in conjunction with the city maintenance program.

- Where possible, widen the creek to increase the flood capacity without decreasing minimum summertime depth critical for fish.

- Reduce the flood potential of constrained reaches or "bottlenecks" such as the Southern Pacific Railroad bridge.

- Create a flexible Enhancement Plan to accommodate possible future flood control projects.

The detailed hydrologic study and monitoring and maintenance programs mentioned in the objectives are not a part of this project and should be conducted separately.

As a part of this project, the existing flood hazard has been reviewed. The Plan is not intended to create new solutions to the flooding problem, but should maintain or improve, where possible, the existing level of flood protection. This issue comes into play where revegetation is suggested in the creek channel, reducing the flood capacity. When revegetation is suggested it should be balanced by increasing the flood conveyance.

At the Southern Pacific Railroad bridge, where the creek's flow is most constricted, several alternatives are suggested for improving the flow capacity to at least equal that of the new upstream bridges.

Goal 5: To the extent consistent with wildlife habitat, flood protection and public safety, **create a safe route for pedestrians and bicyclists along the greenway corridor** linking the neighborhoods, existing trails, public open spaces and the downtown commercial core of the City of Martinez.

Objectives:

- Create a publicly accessible trail system which follows the creek where possible.

- Where the creekside trail cannot accomodate bicycles, develop a seperate trail adjacent to the creek for cyclists.

Because the creek runs through the center of town, it forms a natural link between the residential area, the downtown and the waterfront, providing an excellent opportunity for a pedestrian corridor. Since the creek corridor is too narrow to accommodate a

combined bicycle/pedestrian trail, it is recommended that bicycle trails be developed in city streets, reserving the creekside trail for pedestrians.

Regional bicycle routes and hiking trails such as the Bay Area Ridge Trail pass through Martinez. Connections between these regional trails and the greenway corridor are recommended along City streets, encouraging visitors to explore the downtown area.

Goal 6: Create public, creek related **educational options** throughout the greenway corridor.

Objectives:

- Near the junior high school, provide secured access to the streambed, thereby creating an outdoor laboratory for use in public school and adult education.
- Where appropriate, and consistent with wildlife habitat goals, create overlooks at the banktop with educational exhibits explaining the history and ecology of the creek.
- Develop methods to increase community awareness of the creek
- Where possible, provide a banktop trail which will allow pedestrians to stroll along the creek corridor without disturbing the riparian habitat.

Along the creek, as it moves from freshwater stream to brackish and saltwater marsh, alternative locations for educational exhibits are suggested at special stations or overlooks. At the upstream end of the study area, on the Junior High School property, an outdoor classroom is suggested in the hillside above the top of bank, with a trail leading into the creek (with a locked gate for security), continuing up the stream to provide direct views of aquatic life. The outdoor classroom and trail are intended to be used by the school or other organized groups on a closely monitored basis. The process of restoration itself can be educational, as Martinez residents witness and participate in the revegetation and bank stabilization efforts.

Goal 7: Enhance the economic health of the downtown area through the creek enhancement process

Objectives:

- Promote creek related uses which will attract visitors to the downtown area, such as restaurants, shops and parks.
- Encourage the modification of existing creekside buildings and outdoor spaces, where appropriate, to improve their relationship to the creek. Improvements could include new doors and windows to provide views and access to the

creek, and creekside patios.

- Encourage creek-related development of under-utilized public and private creekside parcels. Appropriate improvements would include the development of creek-related open spaces such as parks, markets or landscaped parking lots. All development should include wildlife habitat enhancements of the riparian zone.

Creation of a greenway can stimulate further revitalization of the downtown. Bicycle and pedestrian trails will provide a new transportation corridor drawing people to the downtown commercial area. As shown in the plan, modification of creekside buildings and properties can stimulate more commercial activity. For example, at the old theater property at Ward and Ferry Streets, the owner could renovate the existing building and create a plaza-like open space near the creek, encouraging pedestrians to pass along the creek while visiting the theater. Similarly the auto showroom on Ward Street and the south side of the Old City Hall building could be renovated to take advantage of the sunny open areas overlooking the creek.

MAINTENANCE AND MONITORING

An important issue implicit in the goals above is that of maintenance and monitoring of the creek, keeping it free of debris, maintaining the existing and future bank stabilization structures, as well as the vegetation along the corridor and the future trails and overlooks. The greenway and trail will be a new open space resource of the City requiring ongoing maintenance. In the Hydrology and Bank Stabilization and the Habitat Restoration and Enhancement sections of this report, maintenance and monitoring recommendations are made.

PHASING AND PRIORITIES

The Enhancement Plan is a vision for the creek which will be realized in phases over a period of time. The Plan can be broken down into discrete projects which may be funded individually and taken through the steps of design refinement, construction documents and implementation. In general, first priority projects should be high visibility improvements on public land. Such projects can be completed without the need for land purchases. Fortunately, a good deal of property along the creek is owned by the City, County, or the school district.

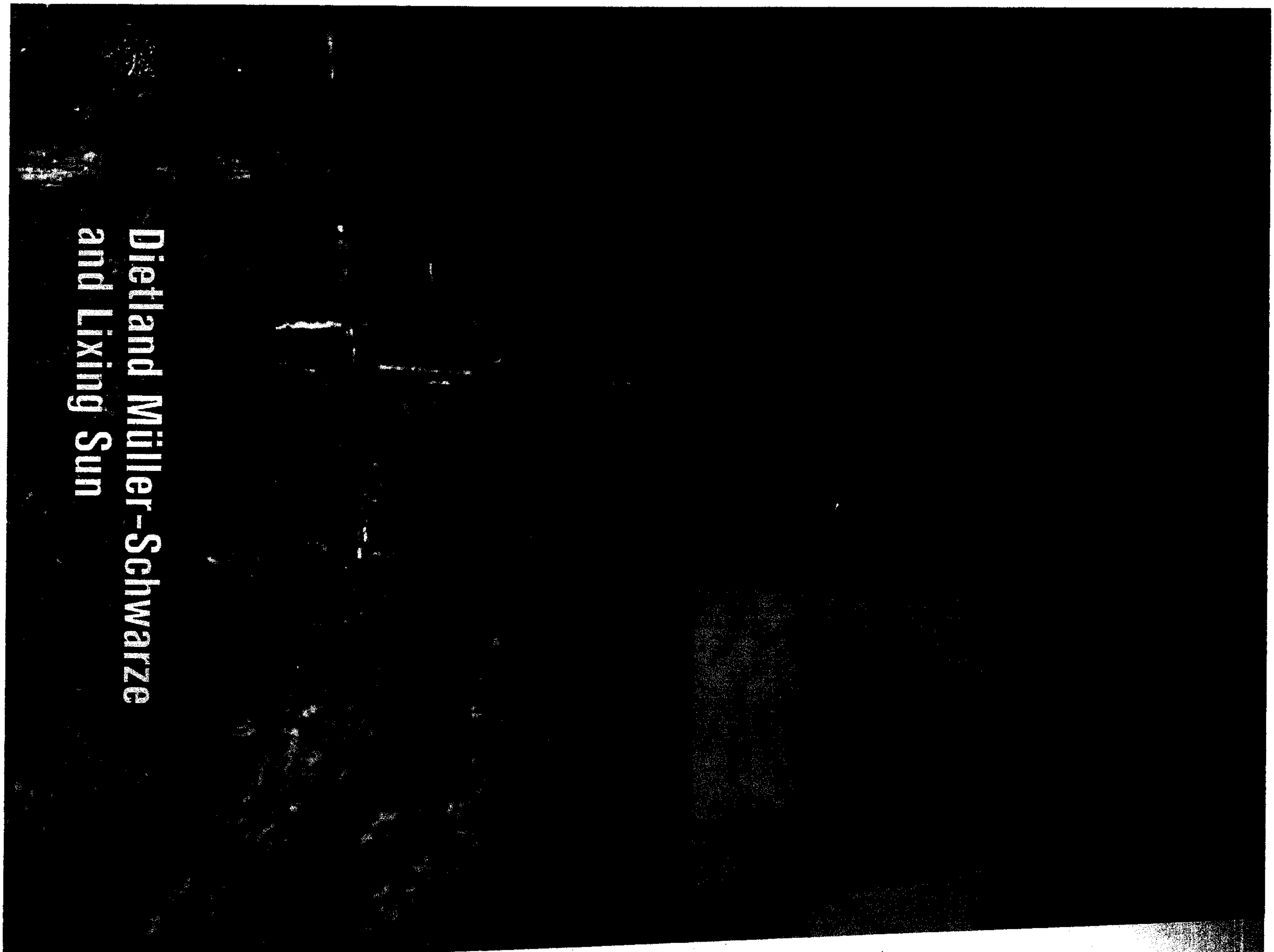
Because the Enhancement Plan is integrated in its approach to access, habitat enhancement and bank stabilization, improvements to each segment of the creek should incorporate all of those aspects at once. Construction of trails or overlooks should occur along with changes to the creek banks and revegetation, as recommended by the Plan.

Access improvements can occur in two overall phases. The first phase would include all sidewalk improvements and street tree planting for the trail, as well as the high visibility improvements to the city-owned parking lots with corresponding development of the areas adjacent to the creek. In addition, the changes recommended on school district property, such as the outdoor classroom and the trail in the creekbed could be part of the first phase. These enhancements should be comprehensive and include educational exhibits, bank stabilization, and revegetation as recommended in the Plan. The second phase of access improvements would involve projects where private ownership of creekside property or privacy of adjacent residents may be an issue. The trail behind the Senior Housing connecting the Senior Center with the existing and proposed housing, would be second phase projects. Also in this category are the recommended changes to the land around the Southern Pacific railroad.

In the areas of hydrology and bank stabilization, two top priorities will be to adopt a creek ordinance, and to conduct hydraulic studies to establish the existing channel capacity in Alhambra Creek. Information on existing channel capacity will be necessary before any modifications in the channel configuration or any significant revegetation within the channel can occur. In addition, water quality testing should be conducted, and sources of pollution, including the hazardous waste sites mentioned above, should be fully identified, investigated and removed. Along the banks where there is no access proposed, bank stabilization improvements will occur as the need arises or as funds become available.

Habitat restoration, like bank stabilization, should occur in tandem with access improvements in the same area. In other areas where there are no access improvements on public property, revegetation may occur as funding becomes available. Where revegetation is recommended on private property adjacent to the creek, planting must occur with concurrence (and participation) of the owner and technical assistance from the City.

Implementation of the Enhancement Plan will require the ongoing commitment of volunteers and staff to continue their involvement as "creek keepers". Ultimately the creation of the greenway as envisioned in the goals must be a cooperative venture among the public entities, dedicated citizens and staff, and the private property owners along the creek.



Dietland Müller-Schwarze
and Lixing Sun

Beaver Fever
Human Contamination

Between 1965 and 1981, 53 outbreaks were reported in the United States, affecting over 20,000 people. *Giardia* cysts are resistant to the levels of chlorination in drinking water that inactivate coliform bacteria. Levels that destroy the cysts render the water unpalatable to humans.[8] When camping, one should take precautions such as boiling, filtration, or chemical treatment, when surface water must be used.

It needs to be emphasized that the primary source of a *Giardia* outbreak is contamination of surface waters by humans. The beaver can only concentrate the parasite put in the water by humans. In that sense, the beaver is not the source but merely a carrier of the parasite. In recreational areas, the infections often come and go with the vacation season. Beavers lose the *Giardia* cysts over the winter and become reinfected in summer. In Fraser, Colorado, beavers upstream of a sewage plant tested negative for *Giardia* but were carriers below the plant.[4] More information can be found in the book edited by Erlandsen and Meyer.[8]

Helminths (worms) have been found in both beaver species. The trematode *Stichorchis subtriquetrus* occurs in the caecum of both Old and New World beavers. The liver fluke *Fasciola hepatica* has also been found in *C. fiber*. Of two prevalent nematodes, *Castorstrongylus castoris* lives in the large intestine of *C. canadensis* and *Travassosius americanus* and *T. rufus* in the stomach and small intestine of New and Old World beavers, respectively. In a study in Alberta, *T. americanus* and *S. subtriquetrus* were common and abundant. They occurred in 93% and 72% of the beavers, respectively.[9] Likewise, in Eurasian beavers, the most common helminths are *T. rufus* and *S. subtriquetrus*, found in 41% and 86% of the individuals, respectively.[10,11] Thus, the genera *Travassosius* and *Stichorchis* constitute the principal helminth fauna of beaver of the Holarctic. They have never been found in other animals. Including the less common species, 11 helminths have been identified in *C. canadensis* and 21, in *C. fiber*.[10] Many of these are restricted geographically or have other hosts, such as muskrats, and mallards.

Ectoparasites

Beetles

The beaver beetle (*Platypsyllus castoris*) belongs to Sylphidae (carrion beetles). Lacking hindwings, it can move from beaver to beaver only during direct body contact or in the lodge. The gut of beetles found on Eurasian beavers at the River Elbe contained beaver hair and epidermal skin fragments.[12] Both beaver species harbor this flightless and blind parasite. These features have spawned debates on whether the beetle—and also the beaver mite—have ridden along as the beaver spread from Eurasia over the Beringia Bridge to North America, or whether transplanted *C. canadensis* infected the Eurasian beaver. The latter is held unlikely today.

HOW DO BEAVERS AFFECT LOCAL HYDROLOGY AND DRAINAGE IN THE DOG RIVER WATERSHED?

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This project examines the positive and negative aspects of beaver dams on a creek or stream. The main negative impact beaver dams have is on the human that builds his home or business near the creek. This work documents beaver dam's influence on the surrounding environment with detailed photographs of the beaver dam and the surrounding areas. The photographs include the beaver dam itself, downstream of the dam, the reservoir that the dam creates, and the homes that are endangered from the flooding possibility. This research also determines the pH, turbidity, and dissolved oxygen (DO) upstream and downstream from the beaver dam to actually document if the dam's presence there in fact degrades the water quality. The beavers do not degrade the water quality but really help it, and the only thing that they are hurting is private property owned by humans.

Keyword: beaver, dam, reservoir

Introduction

Animals that live around our area affect the drainage and local hydrology in the Dog River Watershed, and an animal that is a prime example of this is the beaver. The damming of creeks by beavers in the Dog River Watershed can become a major problem because with the backup of water there is more of a chance of flooding in the local area where the dam is located. The beaver's natural instinct is to build dams for their homes and to build up a reservoir to supply them with food (Rue III 1964).

Beavers are furry animals with a wide, flat tail that looks like a paddle. Beavers are known for their skill at cutting down trees with their strong front teeth. They eat the bark and use the branches to build dams and lodges (homes) in the water. Beavers live in rivers, streams, and fresh-water lakes near woodlands. They are excellent swimmers and divers. They can swim underwater for a half of a mile and can hold their breath for up to fifteen minutes (Brant 1985).

North American beavers (Fig. 1) are three to four feet long, including the tail, and can weigh from forty to sixty pounds. They are the largest rodents (gnawing animals) in the world except for the capybara of South America. Unlike most other kinds of mammals, beavers keep growing throughout their lives. Most beavers look larger than they really are because of their humped backs and thick fur. Beavers usually live in family groups, and the beaver families can consist of as many as twelve individual beavers. But most of the time there are six or fewer. Beavers usually live for twelve years, and their enemies include bears, lynxes, otters, wolverines, wolves, and man. A beaver avoids these enemies by living in the water and by coming out mostly at night to eat or work (Brant 1985).

The beavers are the guardians of our water. By damming streams beavers raise the water level, spreading it laterally across gently sloping valleys, slowing its erosive force, and increasing the amount of water held in soils. The additional water increases both the amount and productivity of plants, and the kinds and numbers of animals, particularly fish (USDA Forest Service 1999). A beaver uses its strong front teeth to cut down trees and to peel off bark and the branches (Fig. 2). The beaver stores some branches deep in the water for use as food during the winter. The other branches may be used to enlarge or repair the dam and the lodge (Brant 1985).

Beavers are one of the few mammals, aside from humans, that can profoundly change their habitats. The dam is started by laying parallel sticks and branches in the streambed, the butt ends facing upstream so that the current anchors the spreading branches more securely in the bottom. The first layer is then plastered with stones, roots, and mud; and again the current aids in packing the silt into the

spaces between the leaves and twigs. The dam is built up high enough to hold back a pond six to eight feet deep. The average finished dam is usually about fifty yards in length, six feet high, and about nine feet through the base (Banfield 1987).

There is a big debate over whether beaver dams are a hindrance to people living near creeks. Beavers, however, can be beneficial to the environment. The benefits of having a beaver dam blocking a creek flow are that it helps control erosion; it reduces sedimentation in streams and rivers, and helps develop new wetlands. These dams also help the wildlife by increasing the biodiversity because they create a better environment for fish and waterfowl, a more stable water supply for wildlife and vegetation, ground water recharge and ground water table elevation and formation of natural lakes and ponds (Beaver Dam Information Site 2004). The disadvantages that are argued are that the beaver dams are hurting the fish, causing flooding in residential areas, and destroying non-aquatic vegetation by the increased reservoir.

There are new policy changes that have resulted from the people that believe beavers are a hindrance instead of a benefit. The state's Animal Damage Control agents have started to lethally remove the beavers, rather than live- trap and release them to a safer location away from the public. Does the lethal removal of these beavers have to be done? The usual plan to restore a river and its tributaries is to get rid of or destroy all dams (man-made or animal generated) to help support river restoration (Holyoke 2004), but does the placement of these dams help these fragile ecosystems survive?

The beaver's return has generally been beneficial to wildlife because of the additional wetland habitats they create. The habitat that the beaver dam creates has aided in the return of the wood duck, a species that was near extinction at the turn of the century. Unfortunately, the beaver's return has created problems for a number of landowners. Economic estimates of beaver damage in Alabama include timber, crops, ornamental plants, and even buildings being damaged.

Animal Control has implemented trapping the beaver as an effective means to reduce the beaver population, especially if the beaver has caused damaged to human owned equipment or land. The Conibear 330 (Fig.3) is the best trap available for catching and killing the southern beaver. This trap usually kills instantly and is almost 100 percent effective in preventing escapes. Other equipment used in catching and killing beavers is the snare, leghold traps, and shooting has shown to be successful (Armstrong Undated).

Current evidence of a beaver dam is in the section of Rabbit Creek that crosses Travis Road in Theodore, AL (Fig. 4). The beaver dam has created a huge reservoir of creek water behind it and may cause flooding to the nearby residential homes. Although, beaver dams do have some aspects that benefit the environment, the question is: Do these benefits outweigh the cost of moving families away from these dams because of the potential flood damage.

Research Question

Is the killing of beavers and destroying the dams they create actually helping the environment and wildlife or just getting rid of a nuisance because of the problems that could affect people living around the dam? The significance of the answer to this question is if the community left the beaver dams alone, would it end up helping the environment and rejuvenating the watershed?

Methods

First, my research question led me to take documentation of the beaver dam to see how the environment was being changed with the presence of the obstruction (Fig. 5). Secondly, I measured the stream width by pacing along the roadway for both sides of the stream to see how much the water in the area has increased from the time the beaver dam was put into place. I then took the measurement I got

from the reservoir and compared it to the measurement that I got for the normal stream's width that was located on the other side of Travis Road. Thirdly, I estimated how close the residence was to the actual beaver dam to try to figure out the danger the house is facing when the creek floods. Lastly, I took water samples from both sides of the beaver dam to see if the beaver dam has made the water quality better or worse. The water was tested for turbidity, pH, temperature, and dissolved oxygen at two locations, one before the dam and one after the dam.

Results

The results from the documentation are that I saw that the reservoir (Fig. 6) made the stream exponentially grow much wider because of the water that was trapped behind the dam. The documentary photographs help to show how much the creek has widened because the beaver dam has impeded the flow of water. The measurement of the outflow part of the creek or the normal size of the creek was twenty-four feet long in width. The reservoir that the beaver dam created is about seventy feet long in width so the beaver dam flooded about fifty feet of land after it was built. The beaver dam length was about twenty-five feet to thirty feet long. The distance the house from the water was about thirty feet and the elevation I estimated was about ten feet, so the danger is very minimal (Fig. 7). This is probably why the residents have not taken any action on removing the beavers or the beaver dam. The test results of my water quality can be seen in Table 1. The pH was the same for both sides, and the pH was acidic probably because runoff from acidic soils and the decaying vegetation. The turbidity was probably different because the water was flowing over the beaver dam and causing the soil from the bottom of the creek to get agitated and float to the surface. The temperature of the water is important because it affects how much dissolved oxygen the water can hold and how quickly nutrients will be cycled through the creek system. The dissolved oxygen and saturation levels for both sites were really low because the beaver dam's expansion caused plants to die and when they rot they take oxygen out of the water (Alabama Water Watch: Water Chemistry Monitoring 2002).

Discussion and Conclusion

The main points of this project are that needless killing of beavers should stop and that knowledge about the benefits of beaver dams for wetlands should increase. The beaver dam does create a huge reservoir that covers a lot of used or unused land, and sometimes if the land is being used the dam can create a lot of problems for the people who own the land. This action of leaving the beaver dams in place would help the Dog River Watershed because the wetlands will be able to grow and rejuvenate, but there are always problems when a species lives on creeks that flow in urban areas. The beaver dam is a great attribute to any stream or creek because it will rejuvenate it to where it was before man altered it. But if the beaver dam is located in an urban area where the rising water could produce a problem for the residents that live near it, the beaver dam will be removed and the creek will suffer.

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Table 1: Results from Water Quality Testing

	Temperature	Turbidity	pH	Dissolved Oxygen	Saturation %
Before the Dam	22.5	5 JTU	5.5	5.3	60
After the Dam	20	8 JTU	5.5	4.5	50

INTEGRATED GREENWAY PLAN

The Draft Enhancement Plan reflects an integrated approach to the design of a creekside greenway. The trails, habitat enhancements and bank stabilization designs proposed have been developed together so that each individual element supports the other. The greenway will unite the city with its creek and reestablish a natural, self-sustaining landscape. A continuous trail system will connect the neighborhoods with downtown, schools, parks and with the regional recreational trail network. People will be encouraged to walk or bicycle in safety to the downtown, with opportunities to stop and enjoy the restored natural setting. Educational exhibits will be available to describe the natural processes of the creek, its historic importance and the process of habitat restoration and bank stabilization. The improved habitat will bring a rich biological diversity into the center of Martinez. Stabilization treatments for the channel, its banks and the adjacent properties will work in concert with habitat restoration and will accomodate trail construction.

GOALS AND OBJECTIVES

The City of Martinez has gathered the community, consultants and staff to create a vision for the creek. One of the first steps was to develop the goals and objectives to guide the process of creating this vision. The goals and objectives were developed from the record of citizen input on past and current creek planning, from consultation with the City staff, and after a thorough analysis of the existing conditions within the study area.

The goals and objectives provide a summary of the desires of the community and the recommendations of the consultants with regard to enhancement of Alhambra Creek. Each goal has been listed here accompanied by related objectives and a discussion of the way in which the Enhancement Plan responds to that goal.

Goal 1: Create a **greenway corridor** along Alhambra Creek which **balances the community desires for public access, natural area restoration, wildlife habitat value enhancement, flood protection and bank stabilization.**

Objectives:

- develop a planting program along the riparian corridor that will support wildlife and fish habitat restoration.

- develop a tree planting program consistent with the riparian corridor planting for streets and other open spaces adjacent to the creek, to visually enhance the spaces, provide shade and widen the riparian corridor.

- limit and control public access in sensitive wildlife habitat areas
- Provide natural and artificial barriers to habitat impacts in high public use areas

Alhambra Creek is a prime candidate for creation of a restored greenway corridor in the one mile stretch of the study area. Restoration and wildlife value enhancement can be achieved with some modification of the creek banks, removal of invasive exotic vegetation, and revegetation with native plants. Public access has been carefully integrated with the goals of bank stabilization, revegetation and wildlife protection. Where the disturbance to wildlife would be excessive, public access is restricted or curtailed. A continuum of natural and urban experiences is provided within the greenway corridor.

Goal 2: Create an access and enhancement plan which maintains the **privacy and security** of creekside properties and residents and the **safety of those using the creek.**

Objectives:

- Develop a public access system which is easily monitored for the safety of the users.
- Develop a public access system which encourages active use by residents and visitors, and minimal conflict with property owners.
- Develop measures to secure the safety and privacy of residents, students and property owners where a public trail or overlook occurs near a residence or school.

To protect the privacy and security of property owners, access to the banktop is primarily restricted to existing public property. The few parcels where access is recommended on private property occur mainly in the downtown area where owners may benefit commercially from the presence of trail users or an enhanced creek environment.

Providing for the safety of those visiting the creek is an important security concern. The recommended trail system can be monitored from public streets or populated areas.

Goal 3: Improve the **habitat values for wildlife** in the riparian corridor and for fish in the creek.

Objectives:

- Preserve the existing healthy riparian habitat.

- Establish an overall vegetation management plan that supports the habitat restoration, bank stabilization, flood capacity, and aesthetic enhancement goals.

- Enhance and restore fish habitat values in the creek.

- Widen the riparian and marsh zones beyond the narrow channel corridor wherever possible, creating buffer/transition zones between the creek and urban areas.

- Buffer fish and wildlife habitat from public use and other urban adverse impacts.

- Create guidelines for consistent bank stabilization treatments for public and private land along Alhambra Creek. Treatments should improve habitat values and aesthetic quality of the creek.

- Improve water quality, minimize water quality hazards and protect public safety.

The riparian corridor is currently quite narrow and isolated from surrounding habitats. Improving habitat values for fish and wildlife can be accomplished primarily by reestablishing and expanding the layered vegetation canopy of the riparian corridor. This revegetation provides habitat for animals, with a variety of native plants offering shelter and food. In addition, trees will provide a dense canopy over the creek, shading it and reducing water temperatures for fish. In many stretches of the creek, where natural banks have been stabilized with manmade structures and the vegetation removed, alternative means of bank stabilization which include revegetation and wildlife enhancement are recommended. Hazardous waste sites which could potentially leak into the creek, affecting water quality and public safety have been identified in the Plan. In the downstream reaches, alternative means of expanding the wetland habitats are explored.

Goal 4: Create an access and enhancement plan that **maintains or improves,** where possible, the **existing level of flood protection** along the creek.

Objectives:

- Conduct a detailed hydraulic study of the project area to ensure that the treatments recommended as part of this Enhancement Plan do not alter existing flood levels.

- Develop a monitoring and maintenance program of the enhancement work for Alhambra Creek for debris and silt build-up and invasive vegetation in conjunction with the city maintenance program.

- Where possible, widen the creek to increase the flood capacity without decreasing minimum summertime depth critical for fish.

- Reduce the flood potential of constrained reaches or "bottlenecks" such as the Southern Pacific Railroad bridge.

- Create a flexible Enhancement Plan to accommodate possible future flood control projects.

The detailed hydrologic study and monitoring and maintenance programs mentioned in the objectives are not a part of this project and should be conducted separately.

As a part of this project, the existing flood hazard has been reviewed. The Plan is not intended to create new solutions to the flooding problem, but should maintain or improve, where possible, the existing level of flood protection. This issue comes into play where revegetation is suggested in the creek channel, reducing the flood capacity. When revegetation is suggested it should be balanced by increasing the flood conveyance.

At the Southern Pacific Railroad bridge, where the creek's flow is most constricted, several alternatives are suggested for improving the flow capacity to at least equal that of the new upstream bridges.

Goal 5: To the extent consistent with wildlife habitat, flood protection and public safety, **create a safe route for pedestrians and bicyclists along the greenway corridor** linking the neighborhoods, existing trails, public open spaces and the downtown commercial core of the City of Martinez.

Objectives:

- Create a publicly accessible trail system which follows the creek where possible.

- Where the creekside trail cannot accomodate bicycles, develop a seperate trail adjacent to the creek for cyclists.

Because the creek runs through the center of town, it forms a natural link between the residential area, the downtown and the waterfront, providing an excellent opportunity for a pedestrian corridor. Since the creek corridor is too narrow to accommodate a

combined bicycle/pedestrian trail, it is recommended that bicycle trails be developed in city streets, reserving the creekside trail for pedestrians.

Regional bicycle routes and hiking trails such as the Bay Area Ridge Trail pass through Martinez. Connections between these regional trails and the greenway corridor are recommended along City streets, encouraging visitors to explore the downtown area.

Goal 6: Create public, creek related **educational options** throughout the greenway corridor.

Objectives:

- Near the junior high school, provide secured access to the streambed, thereby creating an outdoor laboratory for use in public school and adult education.
- Where appropriate, and consistent with wildlife habitat goals, create overlooks at the banktop with educational exhibits explaining the history and ecology of the creek.
- Develop methods to increase community awareness of the creek
- Where possible, provide a banktop trail which will allow pedestrians to stroll along the creek corridor without disturbing the riparian habitat.

Along the creek, as it moves from freshwater stream to brackish and saltwater marsh, alternative locations for educational exhibits are suggested at special stations or overlooks. At the upstream end of the study area, on the Junior High School property, an outdoor classroom is suggested in the hillside above the top of bank, with a trail leading into the creek (with a locked gate for security), continuing up the stream to provide direct views of aquatic life. The outdoor classroom and trail are intended to be used by the school or other organized groups on a closely monitored basis. The process of restoration itself can be educational, as Martinez residents witness and participate in the revegetation and bank stabilization efforts.

Goal 7: Enhance the economic health of the downtown area through the creek enhancement process

Objectives:

- Promote creek related uses which will attract visitors to the downtown area, such as restaurants, shops and parks.
- Encourage the modification of existing creekside buildings and outdoor spaces, where appropriate, to improve their relationship to the creek. Improvements could include new doors and windows to provide views and access to the

creek, and creekside patios.

- Encourage creek-related development of under-utilized public and private creekside parcels. Appropriate improvements would include the development of creek-related open spaces such as parks, markets or landscaped parking lots. All development should include wildlife habitat enhancements of the riparian zone.

Creation of a greenway can stimulate further revitalization of the downtown. Bicycle and pedestrian trails will provide a new transportation corridor drawing people to the downtown commercial area. As shown in the plan, modification of creekside buildings and properties can stimulate more commercial activity. For example, at the old theater property at Ward and Ferry Streets, the owner could renovate the existing building and create a plaza-like open space near the creek, encouraging pedestrians to pass along the creek while visiting the theater. Similarly the auto showroom on Ward Street and the south side of the Old City Hall building could be renovated to take advantage of the sunny open areas overlooking the creek.

MAINTENANCE AND MONITORING

An important issue implicit in the goals above is that of maintenance and monitoring of the creek, keeping it free of debris, maintaining the existing and future bank stabilization structures, as well as the vegetation along the corridor and the future trails and overlooks. The greenway and trail will be a new open space resource of the City requiring ongoing maintenance. In the Hydrology and Bank Stabilization and the Habitat Restoration and Enhancement sections of this report, maintenance and monitoring recommendations are made.

PHASING AND PRIORITIES

The Enhancement Plan is a vision for the creek which will be realized in phases over a period of time. The Plan can be broken down into discrete projects which may be funded individually and taken through the steps of design refinement, construction documents and implementation. In general, first priority projects should be high visibility improvements on public land. Such projects can be completed without the need for land purchases. Fortunately, a good deal of property along the creek is owned by the City, County, or the school district.

Because the Enhancement Plan is integrated in its approach to access, habitat enhancement and bank stabilization, improvements to each segment of the creek should incorporate all of those aspects at once. Construction of trails or overlooks should occur along with changes to the creek banks and revegetation, as recommended by the Plan.

Access improvements can occur in two overall phases. The first phase would include all sidewalk improvements and street tree planting for the trail, as well as the high visibility improvements to the city-owned parking lots with corresponding development of the areas adjacent to the creek. In addition, the changes recommended on school district property, such as the outdoor classroom and the trail in the creekbed could be part of the first phase. These enhancements should be comprehensive and include educational exhibits, bank stabilization, and revegetation as recommended in the Plan. The second phase of access improvements would involve projects where private ownership of creekside property or privacy of adjacent residents may be an issue. The trail behind the Senior Housing connecting the Senior Center with the existing and proposed housing, would be second phase projects. Also in this category are the recommended changes to the land around the Southern Pacific railroad.

In the areas of hydrology and bank stabilization, two top priorities will be to adopt a creek ordinance, and to conduct hydraulic studies to establish the existing channel capacity in Alhambra Creek. Information on existing channel capacity will be necessary before any modifications in the channel configuration or any significant revegetation within the channel can occur. In addition, water quality testing should be conducted, and sources of pollution, including the hazardous waste sites mentioned above, should be fully identified, investigated and removed. Along the banks where there is no access proposed, bank stabilization improvements will occur as the need arises or as funds become available.

Habitat restoration, like bank stabilization, should occur in tandem with access improvements in the same area. In other areas where there are no access improvements on public property, revegetation may occur as funding becomes available. Where revegetation is recommended on private property adjacent to the creek, planting must occur with concurrence (and participation) of the owner and technical assistance from the City.

Implementation of the Enhancement Plan will require the ongoing commitment of volunteers and staff to continue their involvement as "creek keepers". Ultimately the creation of the greenway as envisioned in the goals must be a cooperative venture among the public entities, dedicated citizens and staff, and the private property owners along the creek.

Chapter 15 –Open Space and Infrastructure

This Chapter discusses open space and infrastructure for the Specific Plan area. The intent of this Chapter is to specify the open space and infrastructure facilities proposed to be located in the area and needed to support the land uses. This Chapter is organized as follows:

15.1 OPEN SPACE

15.1.1 Open Space and Trail Network

The Downtown Specific Plan Area lies in the narrow valley of Alhambra Creek, adjacent to over 400 acres of open space in the Regional Shoreline and Waterfront Park. Cemeteries and the Carquinez Strait Regional Shoreline form a green backdrop to the west. Hills to the west and east provide pleasant views of trees and even olive orchards, reinforcing the sense of Downtown as an urban peninsula reaching into a spectacular natural setting.

Several local and regional trail corridors intersect in Downtown Martinez, making it a natural place for trail users to embark, rest or have a meal along their way. Within the Martinez Regional Shoreline, nearly three miles of trails provide close-up views of the marshland habitat and distant views of the Carquinez Strait.

The longstanding goal of a "creek walk" along Alhambra Creek has been largely realized through the creation of the creekside plaza between Ward and Main Streets and the landscaped creek channel improvements from Marina Vista north to the railroad.

This Plan proposes the incremental continuation of the creek walk as adjacent properties and streetscapes are improved in accordance with the Alhambra Creek Plan, as well as a new creekside park with a children's play area at Green and Ferry (Opportunity Site 23). This location is important because it is the intersection of the Alhambra Creekway and the termination of the Ferry Street retail corridor.

Two regional trail systems intersect at the Nejedly Staging Area in the hills west of Downtown. The **San Francisco Bay Trail**, a 400-mile trail corridor encircling the bay, of which 240 miles have been developed, runs along the southern edge of the Martinez Regional Shoreline and through Downtown. This Bay Trail segment also forms part of the **Juan Batista de Anza Trail**, a proposed 900-mile multi-use trail system from Mexico to San Francisco commemorating the route of explorer Juan Batista de Anza. The **Bay Area Ridge Trail** is a planned 400-mile multiple-use trail connecting parks and preserved open spaces along the ridgelines surrounding San Francisco Bay, of which 230 miles have been completed. A dedicated segment of the Ridge Trail runs to the west of

the study area through the Franklin Hills, crosses the Bay Trail/De Anza Trail at the Nejedly Staging area and continues into Downtown. A planned extension of the Ridge Trail to Solano County would run east from Downtown along Escobar and Marina Vista, coterminous with the Bay Trail.

Figure 15-1 illustrates the trail systems described above.

In addition to regional and local trails, self-guided historical walking tours are recommended to provide residents and visitors with opportunities to experience the unique combination of historical, cultural and natural elements that are part of Downtown Martinez. These trails should be illustrated by maps geared primarily to pedestrians and bicyclists. These "urban trails" could be varied in length and emphasis. For example, trail maps and self-guided or guided tours could be related to architecture, the natural environment, people and places in Martinez history, or various combinations of these topics. A shorter trail could focus on the historic Main Street/Ferry Street/Court Street spines. Longer trails could include the Old Town/Granger's Wharf neighborhoods as their focus, while extending north to encompass Downtown's natural elements including the Regional Shoreline, cemeteries, and the Carquinez Scenic Drive.

15.1.2 Open Space Standards

This section discusses park and open space standards in the Specific Plan area.

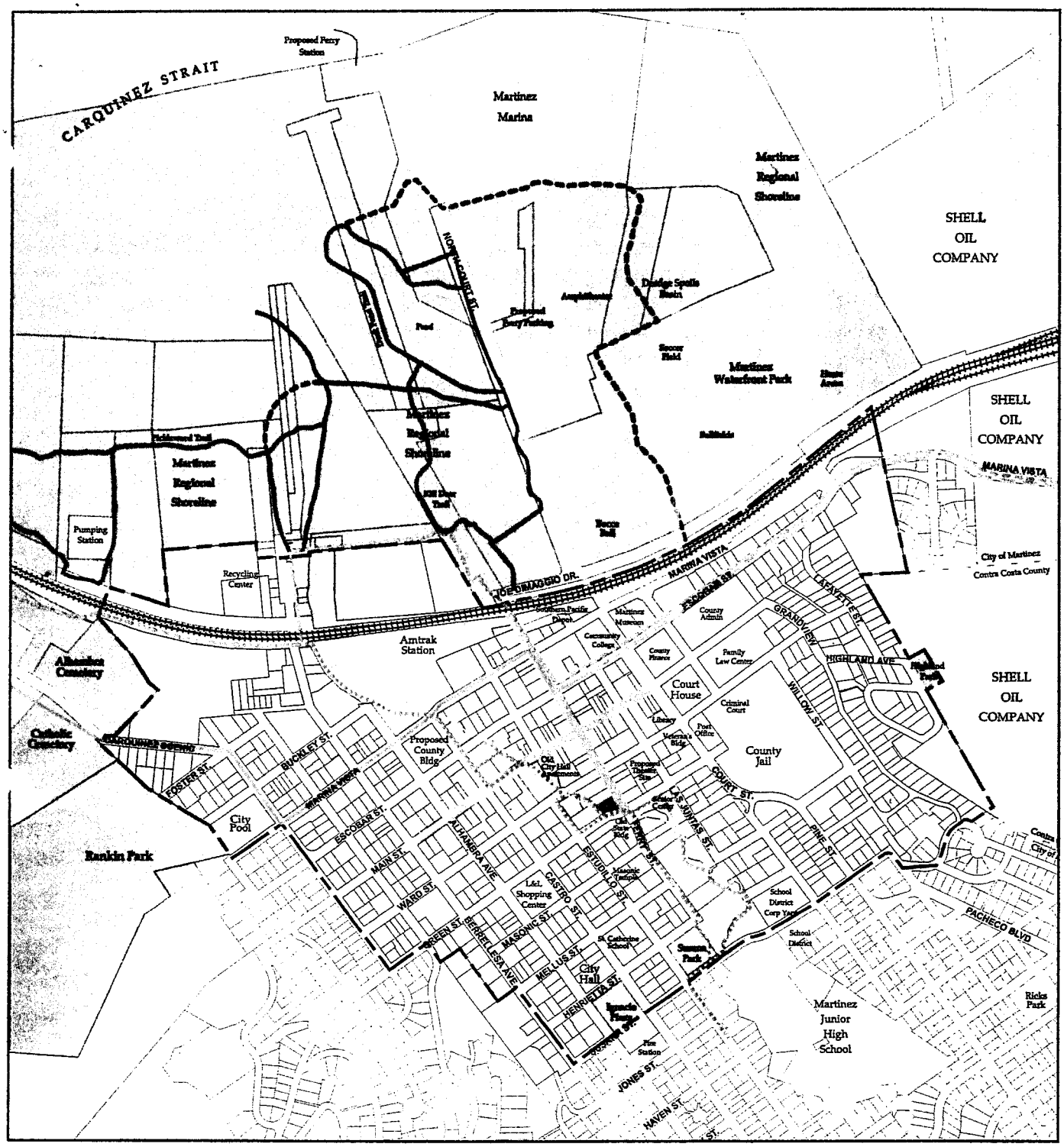
As noted in the preceding section, Downtown Martinez enjoys easy access to a wealth of nearby open space, both active and passive. All portions of the Specific Plan area are within one-half mile or less of the hundreds of acres of developed parkland and natural open space in the Martinez Regional Shoreline and Waterfront Park. Several neighborhood parks and a community park are also located Downtown.

Existing parks and open space in the vicinity of the study area are shown in Table 15-1 below.

Table 15-1, Downtown Martinez Parks and Open Space

Park Type	Service Area	Parks in Study Area	Park acres
Community	1-2 miles	Martinez Waterfront Park	150 acres
		Rankin Park	41 acres
Neighborhood	1/4 to 1/2 mile	Plaza Ignacio	1 acre
		Susana Park	1 acre
		Highland Avenue Park	0.25 acre
Regional	several communities	Martinez Regional Shoreline	278 acres
			TOTAL 471 acres

An additional 77 acres of parkland is located within the City of Martinez but outside the study area, bringing the citywide total to 548 acres. If the Martinez Regional Shoreline is excluded, the citywide total is 270 acres of parkland.



LEGEND

- Study Area Boundary
- Rail Road
- Property Lines
- Alhambra Creek
- Existing Martinez Regional Shoreline Trails
  (Source: East Bay Regional Park District; California Coastal Conservancy)
- Proposed Martinez Regional Shoreline Trails
  (Source: East Bay Regional Park District; California Coastal Conservancy)
- Proposed Trail - Alhambra Creek Enhancemant Plan
  (Source: Alhambra Creek Enhancement Plan, City of Martinez, April 1992)
- Existing/Proposed Bay Area Ridge Trail
  (Source: East Bay Regional Park District)
- Planned Bay Trail *(Source: East Bay Regional Park District)*
- Parks / Open Space
- Proposed Park / Playground
- Pedestrian Priority Streets

Fig.15-1 OPEN SPACE & TRAILS

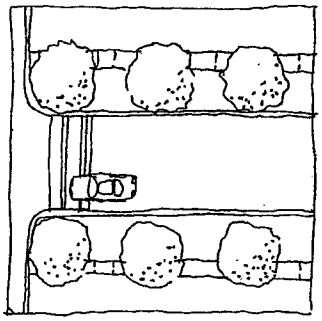
Downtown Martinez Specific Plan

Martinez, California

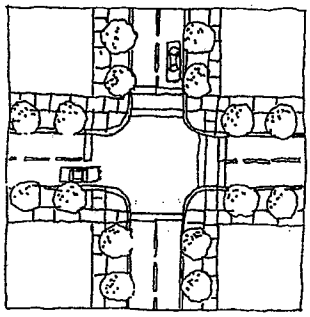
0' 200' 400' 600' 800'

Calthorpe Associates
URBAN DESIGNERS
PLANNERS
ARCHITECTS
Berkeley, California

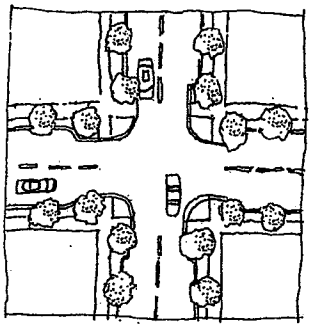
City of Martinez, California



Textured Crosswalk



Raised/Textured Intersection



Knockdowns or Bulb-Outs

Traffic Calming Measures. *A combination of techniques may be used in areas of heavy pedestrian or bicycle traffic to effectively "tame" traffic.*

Inappropriate Measures

Traffic calming measures that are not recommended for the Specific Plan area include the following:

1. *Speed Bumps.* Speed bumps traverse travel lanes with raised strips that are typically 3-4 inches high. The need for speed bumps is symptomatic of road designs that fail to slow traffic. While speed bumps may offer an appropriate method for slowing traffic within certain pre-existing conditions, other methods for slowing traffic should be employed on new streets.
2. *Street Closure and Forced Turn.* Using barriers and diverters works against the creation of an interconnected street network and is not recommended.

14.2 Public Signage for Wayfinding and District Identity

Downtown Martinez currently has several varieties of public signage dating from different eras and in various states of repair. Recent banner signs on streetlamps coexist with wooden street signs from the early 1980s. The City should consider developing a comprehensive wayfinding strategy, given the new uses contemplated in the Downtown, the circulation concept discussed in Chapter 13 of this Plan, and the regional and local trail segments located Downtown. Such a strategy should develop a coordinated design palette for several different types of signage:

a) Signage to direct auto traffic from Multi-Modal Streets to parking opportunities and to the Intermodal Station.
b) Signage for bicycle routes.
c) Signage for regional trails (the San Francisco Bay Trail and Bay Area Ridge Trail/Juan Bautista de Anza Trail)

Map kiosks can help pedestrians locate nearby destinations and encourage walking within the Downtown.

d) Signage for the proposed "creek walk" along Alhambra Creek
e) Street map kiosks to help orient visitors.
f) Transit signage, including transit stop locations and information.
g) Historical markers and plaques.

Many routes, such as Escobar Street, serve multiple functions, making coherent signage all the more critical. On these routes, signs for bicycle routes and trails should be grouped onto a single pole for a more coherent streetscape.

14.3 Gateway/Entry Treatments

In general, gateways to Downtown should be located along Multi-Modal Streets. There are existing gateway monuments at Alhambra and Bertola Streets, where Alhambra Avenue splits into the Alhambra/Berrellesa couplet, and at Marina Vista Avenue where it merges with Escobar Street. These "gore points" where two streets converge into one are natural locations for gateways. An additional opportunity for a Downtown Gateway would be at Pine and Mellus Streets, where Pacheco Boulevard transitions into Court Street, since many visitors to the County complex arrive this way.

The Intermodal Station is, of course, another important gateway to Downtown Martinez. Signage should direct pedestrians exiting the station east to Ferry Street, where the old train station, the entrance to the waterfront parks, and the historic buildings lining Ferry Street create a strong mental image of Downtown Martinez as the intersection of station, waterfront and historic Downtown. The historic train display and September 11 memorial in this area already contribute to the civic focus; additional plantings, coordinated signage or special paving could help reinforce the sense of arrival at this location. A gateway treatment here at the heart of Downtown should incorporate a map kiosk to help visitors plan their expeditions to the many Downtown attractions.

J

Bank Stabilization
Julian Frazer

It is not clear if there are bank stabilization issues due in whole to beaver activity. The burrowing of beaver is quarrying for mud and bank hole for protections these are usually shallow and parallel to the bank . **Stabilization of banks can be many kinds of causes: Non compacted fill, rotting tree roots, other animal sources, abandon pipes and other debris, and can be easily remedied by concrete injection or other simple means, by the responsible party e.g. city or property owners or combination.**

Concern issue raise by an engineer is presented less the objective terms. Information has been given to an engineer that beaver activity is a potential cause for water in the creek causing damage to buildings. The descriptions of the activity is exaggerated, non proven and stated to have occurred in parts on the creek that it has not and in some cases not relatively close the property of concern.

The majority of the buildings in this area are protected by substantial bank stabilization and erosion control, major steel and concrete walls, and a concrete box culvert, typically having a concrete bottom.. Some of which could be affecting the properties down stream in terms of erosion.

Removal of vegetation by beaver can be characterize as a benefit to flood concerns rather than a threat to bank stabilization especially when beaver cut willow trees above the root line and sprouting occurs in spring. The root structure remains and if fact the tree is lese apt to be washed from the bank in heavy flows. All vegetation is not removed as characterized by engineer.

Trees were also cut by prosperity owner of the city. .

Of particular interest is the concern the lodge which is built the east bank which looks to be a former silt deposit placed against a sheet pile and concrete retaining wall going to the bottom of the creek, thus protecting the bank, which is on the other side of the retaining structure, from beaver activity. The eddy that is also mention is this area is a preexisting flow condition.

The engineer armed with partial information has ignored the fact that all these condition were preexisting to the beaver going back to the time before the building were placed in the flood plain and have to continue to occur as a result of increased flow due development upstream increasing scouring in the creek.
In fact even scouring of banks is less when there is a beaver pond.

MUSKRAT AND BEAVER MANAGEMENT IN WETLANDS

PLANNING AHEAD FOR WILDLIFE SURVIVAL

Managed wetlands attract many forms of wildlife including a variety of furbearing mammals. Muskrats and beavers are of particular interest in these areas because they are extremely dependent on wetland habitats and because their activities can have either beneficial or damaging effects on the wetland itself. In some situations, these animals can enhance the value of wetlands for other wildlife. Yet, populations of both must be closely

monitored and occasionally controlled to avoid problems associated with their over-abundance.

Muskrats

Muskrats feed primarily on aquatic plants. In marsh environments their feeding and lodge construction can aid wetland managers in obtaining desired amounts of open water and vegetation. In some portions of their range, muskrats can become excessively abundant and actually destroy the aquatic vegetation upon which they and other wildlife are dependent. Fortunately such "eat outs" are not common in Missouri.

Muskrat populations vary each year depending on their relative reproduction success. Muskrat reproductive capacity is great, thus populations respond quickly to favorable water and habitat conditions. Conversely, drought, disease and excessive animal densities will limit production of this generally stress intolerant species. Muskrats in most aquatic environments can be heavily harvested by man. Muskrat trapping should be an important aspect of integrated wetland management programs. Muskrat trapping makes sense not only because managers can alter harvest pressures to create desired habitat conditions, but also because the fur resource represents a renewable and valuable product of the land.

Muskrats can create problems particularly during periodic populations highs. Perhaps the most troublesome muskrat activity is their digging and burrowing. Many marsh-dwelling muskrats live in lodges. However, some chose the periphery of the marsh and actively excavate bank burrows for protection. In lakes, ponds, creeks and rivers, bank burrowing is a normal activity. Burrowing represents the greatest problem in diked wetlands and pond or lake dams not constructed according to minimum agricultural specifications. Fluctuating water levels aggravate the problem by forcing the animals to continually dig to keep their living quarters above the water level. Vehicles or livestock can cause the burrows to collapse further damaging the dike or dam. Periodic trapping may necessary to control muskrat damage in severe burrowing situations. If animals are removed from bank burrows, it is important to fill the burrow and the den itself with soil to minimize the chance of another muskrat occupying the site. A vacated, but suitable den site is attractive to other passing muskrats and will likely be reoccupied unless the burrow and den are made unattractive.

Trapping with steel traps is the most efficient way of removing muskrats. The small size "conibear-type" instant killing trap is an effective control device when set at den entrances. If done during the open season, the pelts can be sold. However, if damage requires immediate action, any landowner or his agent may trap the animals in his pond at any time, without permit, provided he does not use any part of the animal for food or profit and notifies the conservation agent of his action.

Various chemicals have been tried to keep muskrats out of ponds or to drive them out. Creosote or carbide dropped in the dens through holes opened (with a rod) in the roof has worked in some cases, failed in others.

The same is true of other repellents. The most effective removal is still by trapping; the best insurance against damage is still good construction and management.

Beaver: Economic Importance

The beaver has been called the original flood control engineer. By building series of dams across small water courses he has helped to control water levels and reduce floods on those streams. Beaver keep dams in constant repair and the dams withstand the ravages of minor fluctuations in stream flow.

By building dams, beaver aid materially in reducing soil erosion in certain areas. The running water that enters a beaver pond slows down and automatically drop its load of silt. In time, the pond fills up with silt, forms a meadow and thus keeps the soil there. Otherwise, fine silt suspended in running water would be carried far downstream.

The invasion of a stream by beaver usually results in an ecological succession that provides habitats where increased numbers of plants and animals can exist. The water in beaver ponds provides fish of many kinds with spawning places and/or over-wintering sites. The water is utilized by stock, deer, waterfowl, muskrat, raccoon, mink, quail, pheasant, and many other kinds of wildlife.

The increased variety and amount of vegetation that normally grows around a biologically balanced beaver pond furnishes habitats for various insects, many of which are used as food by fish in the pond. Shrews, meadow mice, and other small mammals invade the area and become established. Ducks and other waterfowl find nesting sites around the ponds.

As a result of flooding, some trees die; their limbs soon break off and fall from the dead trunks and allow the entrance of moisture and fungus, which form holes. Woodpeckers drill other holes in the dead trunks. Those holes provide essential nesting sites for tree swallows, crested flycatchers, bluebirds, titmice and other kinds of birds.

Even after beaver have abandoned a pond, their burrows become homes for other kinds of wildlife. Sometimes well-built beaver dams remain long after the beaver have left and the permanent pond continued to serve the needs of other species of animals.

In places where the water is deep enough to meet the needs of beaver without their having to build dams, the beaver affect plants and other animals less than in areas where dams have to be built. The activities of beaver may in some such places be detrimental to man.

Beaver: Colony Organization and Behavior

The supposition that the beaver family consists of the parents, yearlings and kits is widely accepted by most authorities. A colony consists of one or more families. The number of individual animals per colony varies from 1 to 12 or more, depending upon conditions.

Researches agree that five is near the average number of individuals per colony. Because of the natural tendencies of beaver to disperse, newer colonies consist of smaller numbers.

An established and active colony may consist of only one individual beaver. These beaver were referred to by early trappers as "bachelor beaver."

The weight of the individual beaver gives a fair indication of its age. Beaver weighing 12 pounds or less are no more than one year old, 12 to 25 pounds two years old, and 26 to 40 pounds three or more years old. After gaining weights up to 30 pounds, the rate of increase and the weight both depend to a great extent upon the individual characteristics of the animal.

Beaver mate and have young when three years old. Breeding takes place in January and February. The period of gestation is thought to be between three and four months. The young are born in May and June. The average number of young per litter is four. Older females tend to produce larger litters than young females.

At birth a young, termed a kit, weighs one pound or slightly less. Kits have downy fur, open eyes, and are able to swim a short time after birth. Although the young are able to swim at once, they seldom come out of the den until about 1 month old. Then they swim with their mother who often carries them on her back in the water. The female takes entire care of the kits until this time, but the male soon returns to the family. The young are weaned when about 6 weeks old and weigh 4 pounds.

They remain in their parents' den for at least one year and then continue to live in the colony but inhabit a different den. The two-year-old young are driven from colonies containing younger animals. On this forced migration beaver do not always follow water courses. One beaver in Kansas was obtained nine miles away from a water course. The distance traveled by a migrating beaver is governed by the availability of unoccupied areas having necessary habitat. Beaver generally disperse in late spring and early summer. Once the wandering beaver finds a suitable area and a mate, the pair establishes a new colony.

Beaver are thought to communicate by several methods. One is by slapping their tails against the water when danger is near. Castor mounds sometimes found along the banks of beaver ponds serve as a communication function. The mounds are constructed of mud and small sticks, usually are dome shaped, and are four to eight inches across at the base. Onto these mounds beaver secrete castor which usually is dark red or maroon and has a strong odor. Feces ordinarily are deposited in the water.

After a colony is established it may have several bank burrows. One principal type of bank den has a tunnel leading from a submerged entrance up to an underground chamber located anywhere from six to fifty feet back in the bank above the water level. The tunnel varies from twelve to thirty inches in diameter.

In winter, beaver bring food into the chamber and debris collects on the floor. The beaver enlarge the room by further excavating from the ceiling and walls especially in spring. The chamber often becomes so large that the roof caves in, leaving a large hole in the ground. When this happens the beaver occupying the den are forced to dig another chamber, but when the cave-in is not to extensive the beaver often repair the hole by covering it with limbs and plastering the cracks shut with mud.

Beaver continue to dig new tunnels and openings until some old bank burrows may have several adjoining tunnels each leading to a living-chamber and such dens may have many openings both at the water level and below.

Near a food cache beaver sometimes dig a feeding den, which is merely a pocket under the bank where the beaver feed in concealment.

Beaver seldom construct lodges. Most beaver live in bank dens.

A third type of shelter in which beaver sometimes live is a combination of the ledge and the bank burrow. This false lodge is a dome-shaped structure built by piling limbs and poles on or against the shore of the stream. The beaver tunnels through the sticks and into the bank where the den is located. This type of false lodge may originate from the repairs of a bank burrow that has caved in.

The method of construction which beaver use in building dams always appears to be the same. Branches of cottonwood and will or whatever species of usable plant is most available are cut and placed on the bottom with the larger ends upstream. Mud and gravel, and stones if available are put against the branches. Then other layers of brush are placed upon the first, each in turn weighted down by mud and gravel until the dam reaches the desired height. Most beaver dams are less than four feet high.

At first the water leaks through the loosely constructed dam, but as the current brings down sediment and the beaver bring up more mud from the stream bed and place the mud on the upper side and crest, the dam soon begins to hold water and the pond fills. The dam is kept in constant repair by the beaver. Old dams can sometimes be found with willow trees and other vegetation growing on the the top and downstream side.

A colony of beaver may build several dams depending upon their needs. Dams and ponds are abandoned usually because the food supply becomes exhausted. The time lapse before beaver occupy the same area again depends upon the growth of a new food supply.

From October to December members of a colony engage in a combined effort to cut and store food for the winter. They cut trees that are usually less than six inches in diameter than often fall in the direction of the stream as if planned that way by the animals. This is probably because most trees naturally lean downhill toward the water, and therefore fall that way. Wind may influence the direction in which the trees fall. Trees sometimes wedge against one another and are left as waste although a wedge tree is often saved by

cutting the adjacent tree. Beaver have been found trapped or killed by trees that they had cut.

To fell a tree, the beaver stands on its hind legs and grips the bark with the sharp curved nails on its front feet. It spreads its hind feet wide and braces itself with its tail. While the front teeth drive into the wood like a holding fork, the lower teeth cut a deep notch about three inches below. Then the beaver tears out the chunk of wood between.

Beaver generally cut through a tree by working on one side. A single beaver generally works on one tree, but it does not always work on the same tree that it started on and it may cut nearly through a tree and then abandon it.

After a tree is felled the branches are cut into suitable lengths for transportation to the storage pile. The food is stored from four to ten feet beneath the surface of the water and near the shore and den entrance. The beaver forces the first layer into the bottom and entangles the other layers with the first. The green wood being heavy tends to stay in place.

The size of the food cache varies with the number of individuals in the colony and the amount of food available. During warm spells in winter when their pond is free from ice, the beaver often ventures onto the bank and cut trees. When ice covers the pond the beaver spend most of the time in the dry chambers and their activity in general is greatly reduced.

If the water of a beaver pond is clear a person can often find dens in which beaver are living by watching for the discarded limbs in front of the entrances. These limbs are light yellow having had the bark recently stripped from them.

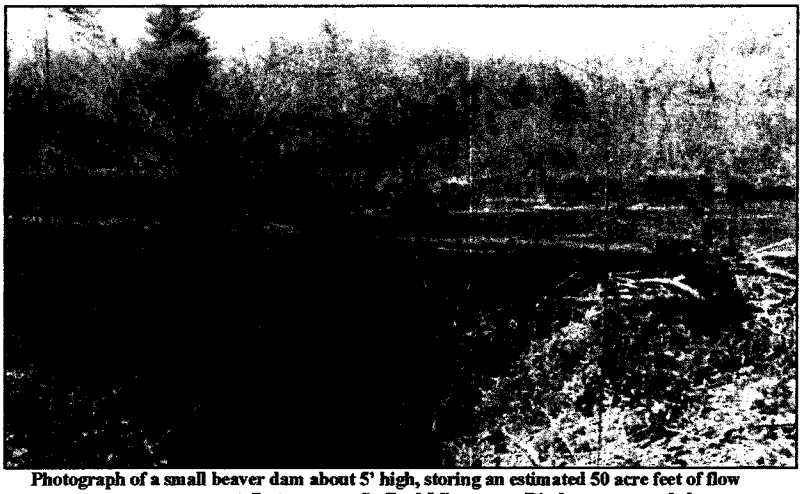
In areas where there are large numbers of springs or fast moving streams, beaver sometimes store no food and rely on food that they obtain as needed from the shore. Feeding in this fashion may be more common where the normal winter temperatures remain high enough to permit a stream to maintain an ice-free flow all year long.

In spring and summer beaver seem to depend less upon bark for food and utilize aquatic plants and the tender green shoots of terrestrial plants. Plants of this kind found cut by beaver are as follows: Ragweed, Pigweed, Sunflower, Smartweed, Cattail, Bulrushes, Sedges, Corn, Maize and others found growing near the water's edge. Cornfields bordering beaver colonies often have well-worn trails over which the beaver drags the corn stalks into the water. Non-woody vegetation is estimated to constitute three-fifths of the beaver's annual food.

Large trees are sometimes gnawed on by beaver in summer. Gnawing wears away the ends of the evergrowing incisor teeth that otherwise would grow so long as to cut into the lower jaw, block the mouth, and cause the beaver to starve.

Evaluation of a habitat for beaver should be based upon the supply of suitable food within 200 feet of deep water -- the nearer to the water the better. Danger of predation increases with distance the beaver has to travel to obtain food. Beaver tend to utilize small trees more completely than larger trees and those with smooth bark are eaten more completely than those with rough bark.

Beaver Dam Information Site



Photograph of a small beaver dam about 5' high, storing an estimated 50 acre feet of flow reserve on a trout stream tributary, near St. Paul Minnesota. Discharge stream below feeds into a trout stream. This dam is the second of a series of 3 similar raises within 200

This site is dedicated to one of the primary keystone species, the beaver. A keystone species is one that modifies the natural environment in such a way that the overall ecosystem builds upon the change. The ponds, wetlands, and meadows formed by beaver dams increases bio-diversity and improves overall environmental quality. It is our opinion that many environmental decision makers do not fully understand the positive effects that beavers and dams bring to ecosystems. This is understandable, because beavers had been virtually eradicated prior to the development of modern scientific methods. This site incorporates first principle engineering concepts in combination with environmental observations to illustrate the extent that our watersheds have changed with the removal of beavers. Beavers affected our ecosystems and land in a very extensive and positive way. Modern society has recently begun to realize the benefits of wetlands. This realization marks a turning point in over 300 years of extensive wetland eradication. Beaver dams are the primary natural method of establishing wetlands. Beaver dams represent the only natural methods of forming lakes, ponds, and wetlands in most watersheds. The exceptions to this would be glacial lakes, or lakes formed by geologic activity. This website is designed to show the numerous benefits of beaver dams.

Benefits of Beaver Dams

- Nullifies "ditching effect" on water tables caused by deepening river and stream channels.
- Reduces channel scouring and stream bank erosion.
- Erosion mitigation.
- Reduction of sediment loading in streams and rivers.
- Development of new wetlands.
- Increased biodiversity including a better environment for fish and waterfowl.
- A more stable water supply for wildlife, and vegetation.
- Ground water recharge and ground water table elevation.
- More cold water springs charging rivers and lakes.
- Longer land water retention time in water cycle since subsurface flow is slower than stream and river flow.
- Flood mitigation due to increased ground water holding capacity. (More capacity then the ponds themselves!)
- Dampening of stream flow rate variations and stream charge during drought cycles.
- Formation of natural lakes and ponds, and maintenance of existing ponds.
- When dams ultimately silt in, natural fertile beaver meadows form

Illustration credit: Reston Association

- Stills and deepens waters, improves canoeing.

Still waters above dam in previous photograph allow sediments to settle

Causes of and Effects of Wetland Removal

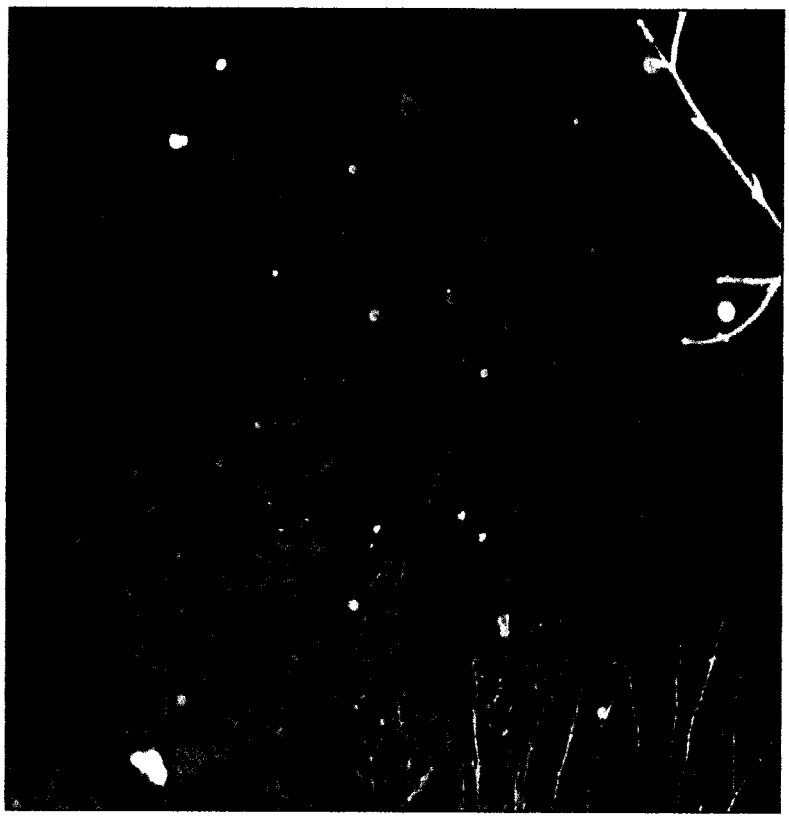
Most blame agricultural drainage and land development as the primary reasons for wetland loss. We do not think about the removal of beavers because we have no modern experience with this effect. Modern agricultural drainage may have less effect of wetland reduction, than the original removal of the beavers. Land drainage in the form of ditching and tiling is a relatively new phenomenon, so the cause and effect of changes can be better quantified. We can see a ditch, but cannot see the absence of a beaver dam. We know of no scientific articles that have actual hydrologic data describing the effects of removal of beaver dams on a large scale. A visualization experiment may be useful. What do you think removal of 250,000 water retention ponds and wetland areas ***per State*** in the Unites States would have on: 1) Flooding; 2) Groundwater recharge and quality; 3) Maintaining constancy of ground water tables and streams levels in periods of drought? Donald L. Hey has written an excellent scientific paper on this topic that was presented to the Annual Meeting of The American Institute of Hydrology 2001 titled, "Modern Drainage Design: the Pros, the Cons, and the Future." This paper states that watershed policies of agricultural and urban drainage have worsened flooding and drought effects. Our watershed management decisions must be made in the context of understanding the original extent of the effects of beaver dams. Of course, it would be impossible to restore all of the wetlands, but the benefits of wetlands should be considered when choices are available.

Stream Bank Erosion and Stream Sediment Loading

One specific example of the missed opportunity of beaver dams is in stream bank erosion and stream meandering. Numerous textbooks state that stream meandering is caused by physical processes seeking equilibrium energy dissipation rates. It is also taught

Unstable stream bank (white dots are blurred snowflakes).

that equilibrium will be achieved when the rate of streambed erosion equals the rate of deposition. Given that beaver dams dissipate flow energy, and change channels into stilling pools, why aren't there chapters on beaver dams in most geomorphology textbooks? Stream channels would be more stable as still interconnected ponds with energy dissipating steps. Currently, these eroding banks are far from achieving a state of "equilibrium" and will continue to scour both deeper and wider. One alternative method to stop stream bank erosion and meandering would be to restore beaver dams in these erosive meandering areas. The photograph to the right shows an unstable stream bank about 6 feet high. The width of the channel is 20 feet. Tree roots and vegetation are temporarily maintaining the unstable high angle of repose. This condition is not stable. The topography of the ravine in which this stream flows is a flat 200 yard wide meadow between steeper ravine side slopes. It is apparent that the stream channel is gouging deeper into the meadow. The sediments from the bank erosion will be washed downstream, ultimately into the Mississippi river. The depth of scour (unstable bank height) is the result of the change causing the instability. In most cases this will have been the removal of the original beaver dams. It is estimated that the beavers were originally removed from this area 150-250 years ago, and that the original dams deteriorated after this time. Beavers have recently returned to this area and have begun building numerous small dams, including the one in the picture (below) which is 150 yards downstream from this location.



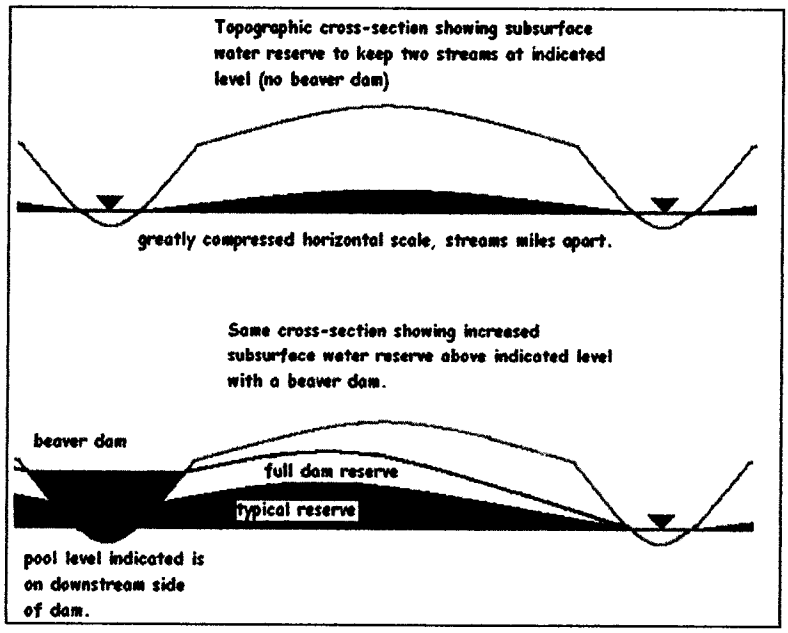
Newly started beaver dam downstream of eroding stream bank in previous picture (White dots are blurred snowflakes)

The new beaver dam in the picture to the left is about 3 feet high. Repeating the previous paragraph the location of this dam is below the unstable stream bank area 150 yards upstream. This dam triples the upstream depth compared to the downstream depth. Any increase in width or depth of a stream channel (cross section area) will reduce the stream velocity in proportion to the increase in width times depth. Upstream of the dam, sediments are being trapped because of the reduced velocity. The upstream area will silt in and if the beavers are left undisturbed, the dam will continue to be raised until it actually tops the channel bank and will be built wider – beyond the scoured existing banks. The sediment stilling effect becomes more pronounced as the pond gets wider. Ultimately, all of the erosion potential of the previous photograph would be stopped. The meadow and wetland would be restored! Rather than having several hundred yards of eroding stream bank loading the stream with sediments, there will be a single dam slowing the water, stilling the sediments, and dissipating the erosive energy. A part of one the original ancient dams that

formed this meadow still exists in this area, it is 12 feet high with a base width of 30 feet. It is located at a point where the ravine width narrowed to about 100 yards.

Several questions in emails have been raised regarding habitat conflicts between beaver dams and fish. If the area depicted above this dam is restored to a wetland/meadow will it be suitable for the same types of fish? The answer is that our notions of natural stream channel profiles are incorrect. It is necessary to recognize the scouring/deepening channel in the stream bank photograph above as unnatural. If the ultimate outcome for the floor of this ravine area is a pond or wetland, there will be a change in the habitat. The pond will be suitable for some types of fish depending of the sediment, nutrient, and pesticide loading levels. The benefits of wetlands and meadows caused by beaver dams are typically seen downstream. Wetland buffers upstream of lakes, for example, improve lake water quality by reducing sediment and nutrient loading into the lake.

Beaver Dam Effects on Watershed Subsurface Water Reserve

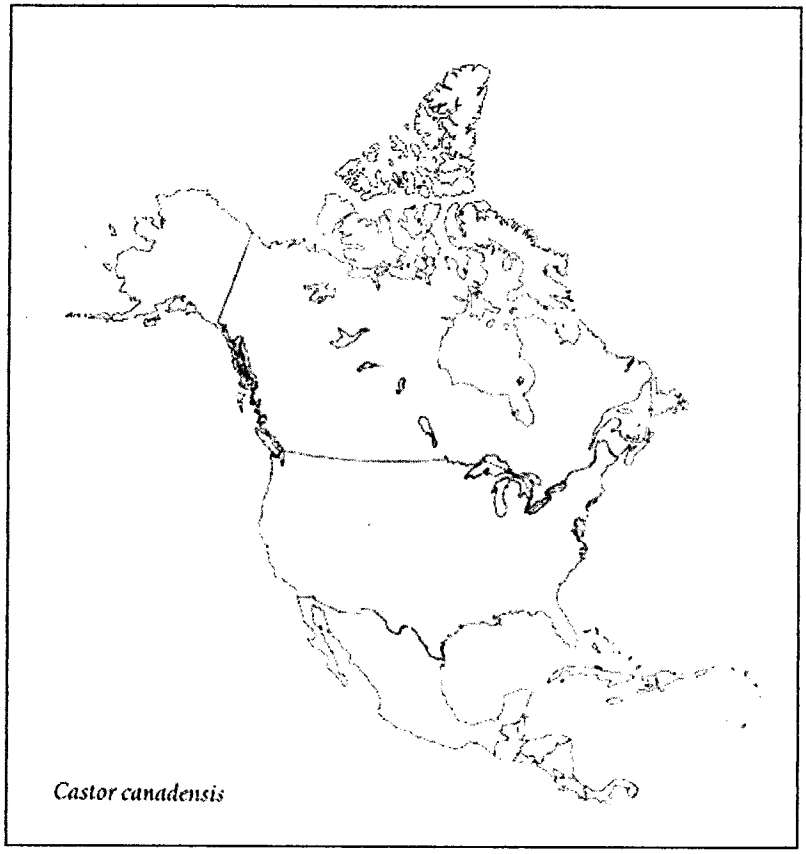


Cross section slice representing two streams (streams flow out of the page).
Blue ground water reserve keeps streams flowing until the reserve reaches

The illustration to the right depicts how beaver dams in stabilize stream flow rates. The illustration shows a horizontally compressed cross section between two streams, and how groundwater charge keeps the stream flowing. The river channels are the "U" shapes and the water flows towards you. Groundwater charge is the reason streams continue to flow without inputs such as rainfall. Water will continue to fill the stream until the level of the black triangles is reached. The top illustration shows the surface profile, and the groundwater levels for typical rainfall conditions with no beaver dam. The bottom illustration shows the elevation of the groundwater table under the same typical conditions with a beaver dam present. Beaver dams naturally leak, so the stream will continue to be fed until the level of the black arrows are reached. Notice that the "typical reserve" is greater in the bottom illustration, and that an additional storage buffer exists for wetter conditions. This wet condition buffer is represented by the white area "full dam reserve" and provides storage for flood mitigation. The blue area is the water charge, and the curved top is caused by rainfall. The effects of beaver dams in increasing the charge of aquifers reaches (sideways) across to the next watershed, and upstream as far as the pool is raised! The increased "typical reserve" behind a beaver dam is of significant benefit to wildlife and fish during periods of drought. The benefits are also seen downstream since beaver dams inherently leak as do charged aquifers. Water springs are the result of water flowing out of charged aquifers. These springs can occur above and below the stream surface. They tend to be moderate in temperature at the average seasonal

temperature.

**Cold water spring in proximity to beaver dams.
These springs also occur in streams but cannot be seen!**



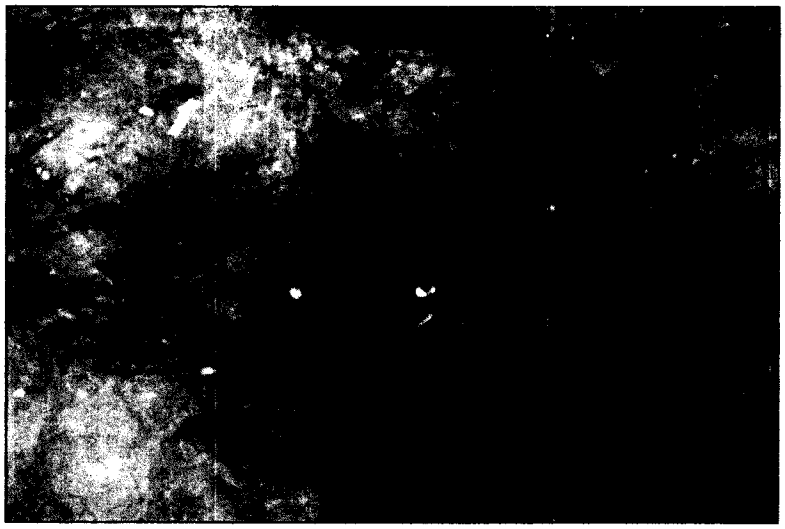
Original North American Beaver Range Map

North American Beaver Range

Beavers covered most of North America prior to 1700. It is estimated that over 60 to 200 million beavers populated the range shown on the map. The beaver's influence touched every watershed in North America. Assuming 100 million beavers in the United States and 8 beavers per dam, there may have been an average of 250,000 ponds per state! Beaver dams significantly influenced erosion/deposition patterns over the entire country. The sediments that were dislodged from the naturally vegetative covered land were often recaptured in the natural stilling ponds created by beaver dams. Water after passing through beaver ponds and wetlands was of better quality with reduced sediment load. The natural energy dissipative characteristics of the spill side of these dams further reduced the erosive potential of flowing streams. Erosive energy was dissipated in the seepage through, and over the beaver dam.

In the 1805 Lewis and Clark expedition up the Missouri River, beavers were observed wherever the habitat was suitable for them (EPA News-Notes). The water transportation systems of the Native Americans also must have been assisted by the numerous beaver dams. The elevated water tables also improved the vegetative ecosystem.

Beaver Dams and Fish



Trout in stream below dam in first picture

Beaver dams pose no unnatural hindrance to fish and may actually beneficial to such native cold water fish as trout. Beaver dams were the norm prior to 1700 in North America, fish and beavers had to have evolved together (reference above 250,000 dams per state)! The height of beaver dams is typically less than 10 feet. Fish migrations are seasonal, and typically occur in the springtime. In the spring high flows often overtop dams, and the downstream water level approaches that of the upstream side of the dam. The fish that evolved under pristine conditions in North America can easily swim over dams in these conditions. These flow conditions in the northern latitudes usually occurred in the spring when the water was colder. This presents a clear advantage to trout and similar native species over warm water species such as carp (non native). The temperature of the water charge during low flow periods will be cooler given the fact that low flows in rivers are the result of groundwater flow. In most climates low flows (droughts) occur during the summer season. Groundwater most always recharges rivers and streams during droughts at the average seasonal temperature. Trout seek these cool spring fed areas during the warmer weather. In some cases, as previously discussed, beaver dams will form wetlands and meadows, in this case the benefits to fish are seen downstream of the dams, with improved water quality in downstream lakes and streams.

Landscape Differences with Beaver Dams

Geomorphology is the study of changes of the earth's surface over time. A number of plants and animals have a significant effect on the type of changes that will occur. Prairie dogs, for example, reverse soil compaction improving permeability and rooting conditions for plants. Earthworms significantly affect the ability of the soil to absorb water during a rainfall event. Trees, grasses and

other vegetation stabilize soil. Tall prairie grass in particular tends to enable the filling in of "micro gullies" that if unchecked would become larger gullies. This grass "lies down" during overland flow, protecting the soil, and allowing sediments to fill in small erosive starts. Beavers work on a macro scale creating ponds that support other life forms including fish and waterfowl. The natural sedimentation in beaver stilling ponds reduces downstream sedimentation, and ultimately forms flat fertile wetland and grassy areas called "Vegas". The term Vega is Spanish for fertile valley, and refers specifically to a silted in dam or natural beaver meadow. UNM Sevilleta LTER Vegas occurred more commonly in mountain areas where erosion rates were naturally higher. Ranches, farms and cities were built on these natural flat fertile areas. Beavers had to be reintroduced in some of these Vega areas to stop the erosive processes that greatly accelerated after the beavers were removed.

The natural geomorphologic outcome for continents without beaver dams will include more ravines and steep valleys, due to the cutting erosive forces of flowing water. As inland river channels deepen, streams that flow into the main river will form. These streams concentrate the precipitation flow, which increases the scouring (deepening) of the river channel. This deepening effect amplifies itself. This is the reason that rivers form. The deeper channels increase erosion rates, leading to distinctive ravine topography. The ultimate result of this system will be low and flat topography, with the finer sediments washed into deltas. Beavers instinctively build dams in areas of more rapidly moving water, which reduces scouring – reducing channel deepening. Beaver dams typically bring the water surface to the top of the riverbank. The sediment deposition in beaver ponds also counteracts scouring (channel deepening). Prior to 1700 many streams and rivers may have been actually a series of ponds with steps (dams) between them. Early geologists observed this step topography. A very large number of beaver dams will shift precipitation flow from rivers and streams into more overland flow, and underground flow towards the ocean. Overland flow and underground flow are slower than stream flow (for equivalent rates), which reduces peak flow rates in rivers after a precipitation event. Reduction of peak flows reduces flooding and erosion. Underground flow certainly resulted in no surface erosion.

Erosion in itself is a natural process; there will ultimately be equilibrium between fine soil formation and erosion. Under natural "pristine" conditions with beaver dams the amount of fine sediments present on the land at any time was significantly higher than with current agricultural and development land use patterns. The greater amount of fine sediments contributed to greater fertility and biodiversity. Agriculture and land development currently play the major role reducing soil equilibrium amounts. The textbooks referred to this change in equilibrium as the land "wearing out". Actually, loss of fertility may have been the result of the loss of the very fine sediments that had been captured in grasslands for eons. Current land use has so radically increased erosion that dammed ponds totally silt in a period of a few years. Research needs to be done to determine the optimal balance between wetlands and agriculture. Progressive thinking may show that sustainable agricultural production and environmentally sensitive land management practices can be achieved with the same land usage practices. The current understanding of the benefits of wetlands and the basic concepts reviewed here should cause us to seriously reconsider the positive effects of beaver dams on ecosystems.

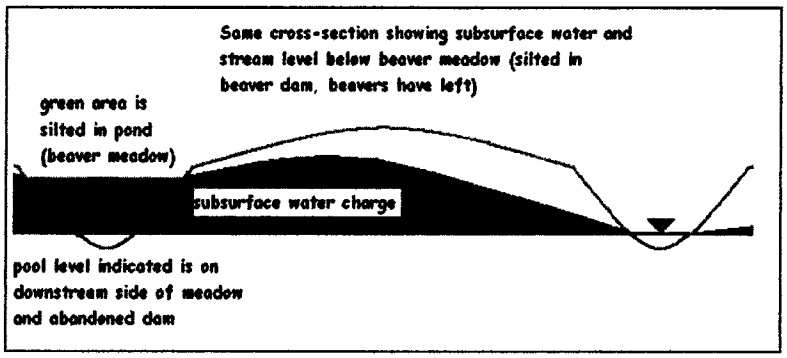
Conflicts with Beavers

There was an inherent conflict between early agriculture and beavers. The fertile land flooded by beaver dams was prime farmland. The beaver fashion hat industry may have developed as a by-product of the early efforts to clear agricultural land in Europe. Most of the early the fur trade, led initially by the French voyagers, the North West Company, and the British Hudson's Bay Company, drove settlement of North America. The beaver pelt was one of the most valuable furs, leading to virtual extinction of beavers in the early 1900's. From a historical perspective it is interesting to note that the greatest harvest rates of beaver pelts in the Lake Superior region occurred prior to the signing of the United States Declaration of Independence. The few beavers that were left when land was homesteaded were likely removed since they were a hindrance to farming. Later government agricultural drainage programs went even further to reduce wetlands. Modern agricultural drainage programs may have had less effect on wetland reduction than the earlier removal of the beavers.

Another current area of conflict with beavers is that they tend to preferentially built dams that interfere with road crossings over flowing water: they especially tend to plug up culverts (if you have an original picture of this send it and we will post it with an illustration credit). The reason for this is that the designs for road crossings tend to constrict the flow which speeds up the water, and tends to

make riffling sounds. The sounds of flowing water in addition to a velocity threshold compel beavers to build dams. Clemson University has developed a correction for this problem with the "Clemson Pond Leveler." This device is designed to quiet the sound of water and to reduce the directional velocity. A long term approach to this problem is to "just stop" constricting streams. Multiple box culverts and bridges are less constricting than single round culverts. Streams should be wider, deeper, and slower at road crossings. Our highway and waterway engineers need to be taught that constricting streams will inevitably lead to beaver problems (and associated costs). The potential for Beaver dam problems should be considered in all water project environmental impact statements and benefit cost analysis. It may be cheaper to just kill beavers, but it is more socially appealing to reduce the potential for beaver problems in the design phase of highway projects.

Benefits of Beaver Meadows



A silted in beaver pond (beaver meadow) continues groundwater storage benefits.
As with a beaver dam the stream below the meadow will continue to be fed with cool ground water.

There is currently a debate going on over what to do with silted in ponds. The two sides of the debate seem to be to either remove the dam and restore the river to an "unobstructed" state or to dredge the sediments out of the pond. It is unfortunate that the ponds have sedimented in so quickly! Total removal of the dam would result in the captured sediments being washed away resulting in years of very high sediment loading downstream. Removing the excess sediment would be expensive, since the pond will just silt back in. Erosion preventative land use practices and upstream stilling sediment catch basins may be a partial solution. The natural model would give some insights. In some cases the beavers continued to raise the pool level, in other cases they would leave and build upstream or downstream. The high sediment loading rates add a complex dimension to this problem. Even so, environmental decision makers must realize that the flat beaver meadow areas left after pools silt in are natural phenomena and these may provide excellent park and recreation opportunities. The stream will flow through the beaver meadow, but the dam forms a natural energy dissipating drop structure. This grassy meadow will flood during high flows, and will continue to capture sediments. The elevated water table caused by the meadow will still contribute to charging the lower stream during periods of drought. The full subsurface reserve would still exist and the silted in pond volume will now be part of the subsurface reserve. The exact hydrology of this system varies, but beaver dams and meadows always increase the subsurface water charge. This concept is shown in the illustration to the right.

Pond above a mature beaver dam,

The following links substantiate the ideas presented on this page. If you want your page linked here please write!

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Clemson University
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The ideas on this page originated from coursework in the Agricultural Engineering Department at the University of Minnesota. The author, Steven G. Grannes has a Master's Degree in Agricultural Engineering with an emphasis in Soil and Water Management.

Last Updated: 29 June 2007

the Beaver

Natural History of a Wetlands Engineer

near their streams. But plant diversity, taking into account plant dominance, was lower at sites beavers had inhabited for 10–20 years than where beavers had not been allowed to colonize. Especially deciduous trees over 25 cm in diameter were scarce. Beavers' foraging resulted in a higher basal area (the sum of the cross sections of all standing trees) of all woody stems, but the basal area of coniferous trees did not differ from that in sites without beavers. Trees preferred by beavers such as alder (*Alnus rugosa*) and aspen (*Populus tremuloides*) had a larger total basal area where beavers lived. Possibly the animals had stimulated new growth by cutting these trees repeatedly, opening up the canopy and permitting more light through.[11]

In the Netherlands, European beavers appear to change a willow-dominated riparian forest in the direction of less diversity as they selectively cut the rarer nonwillow species to supplement their willow diet.[12]

Similarly, as reintroduced beavers spread to new streams in Bavaria and flooded woodlands, ash thrived around the beaver ponds, while spruce died. Selective cutting changed the mix of trees: near the water, ash, poplar, and elm decreased in relative frequency, and distant from water, willow and poplar trees became less numerous. Dam building raised the water table by 30–50 cm (12–20 inches), which in turn favored certain woody species.[13]

Insects and Other Invertebrates

Aquatic insect populations are greatly affected by beaver activity. Mosquitoes become less numerous in beaver ponds, and the species composition of their populations changes.[14] In general, gravel-loving aquatic insects such as stoneflies will be displaced by silt-dwelling species, such as mayfly and dragonfly larvae.[15] Beavers can even have an impact on terrestrial insects: white pine weevils (*Pissodes strobi*) invaded a white pine (*Pinus strobus*) plantation that had been established in partial shade of bigtooth aspen (*Populus grandidentata*). This happened after beavers cut down the aspen and thus provided ideal conditions for the weevil.[16]

In four boreal headwater lakes in Ontario, Canada, beaver lodges with their decaying wood added greatly to the animal abundance of the otherwise rather barren shoreline of sand and rocks. Only 7 taxa were more abundant in sand and rocks: trichoptera, beetles, oligochaeta, 3 fishes (slimy sculpin, brook stickleback, and fathead minnow), and tadpoles of *Rana clamitans*. By contrast, 14 taxa occurred primarily within 8–10 m from the beaver lodges. Total densities of benthic macroinvertebrates were almost 3 times higher near beaver lodges than at sandy and rocky shorelines. Likewise, the densities of animals in the open water were more than 3 times higher here. On the other hand, only water above rocks harbored crayfish, while beaver sites lacked them.[17]

Fish

Beavers affect fish in both benefi
vers provided a greater volume of w
tent stream flow, and an increased
plankton in beaver ponds was 5 tin
species were more varied and abun
short, the beaver activity increased tl
fishes.[19] Warm-water fish, or mud n
beaver ponds but will die when the
the dam is good habitat for northe
(*Micropterus domomieui*).[15] Beaver
spawning runs of trout, northern p
and others. Whether migrating fish
discharge from the pond. In spring,
the dam more easily.[8] Water flowing
tion. On the other hand, beaver p
during severe droughts. Trout may f
ter droughts or winters, fish recolo
the environment is more stable and

The steeper the stream gradient
dam building. Frigid mountain wa
mum, while impounded low-gradi
even toxic for trout. Thus, in the Ar
be more detrimental than beneficial

In the Californian Sierras, beave
the gravel, which the native golde
Brown and rainbow trout displace
cannibalistic, and the rainbow trou

Coho salmon use beaver ponds
low-water periods in late summer.[2
salmon (1.43/m^2) in the Fish Creek
Oregon was 4 times higher than th
than that in riffles. Although a bea
at Fish Creek, it produced 50.4% of
1985.[21] In winter, beaver ponds alo
salmon (about 1 fish/m^2) when co
water pools, trench pools, glides,
represented only 9% of the habita
found.[22] Likewise, a series of deser
important winter habitat for coho

Beaver Influence on Fisheries Habitat: Livestock Interactions

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61 Lower Beaver Creek, Twisp WA 98856

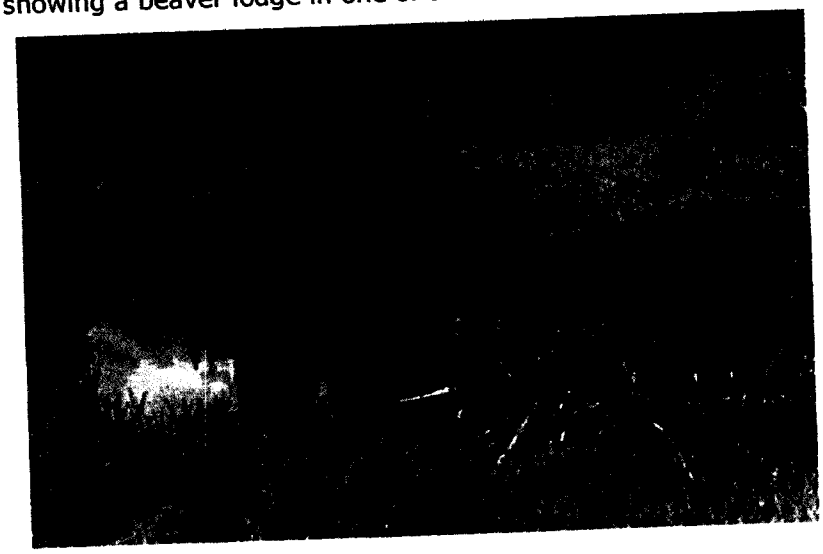
Abstract: This paper will address how livestock grazing interacts with beaver colonies and the potential impacts on watershed ecology and hydrology. The introduction of livestock into the rangeland watersheds of the Inter-Mountain West, degrades stream structure, and places cattle and sheep in competition with beavers for the utilization of riparian vegetation. Where the influence of livestock results in the reduction of beaver populations in watersheds, fisheries habitat and downstream agricultural productivity can be impaired. Observations based on recent and historical reintroductions of beaver can provide guidance for improved management of public land watersheds and their fisheries.

Introduction

Both humans and beavers harvest natural resources and enhance their economies by building structures which alter stream dynamics and watershed ecology. The results of these activities often create conflict between humans and beavers as each compete to control and utilize resources. Where these conflicts occur, beaver are commonly perceived to be a nuisance and much effort is expended to remove them. Less effort has been expended to understanding how human activities, by disrupting beaver population distribution and reducing beaver habitat suitability, undermine the beneficial influence of beavers on watershed ecosystems and fisheries habitat.

Beaver habitat may be part of wetlands and side channels associated with riverine or lacustrine environments. The focus of this paper and much of the reviewed literature is about the effects of beaver dams impounding 2nd to 4th order streams. In larger streams with greater hydraulic forces, beaver dams are temporary and have less influence on the character of the stream, however, beavers commonly build dams in side channel and backwaters of riverine systems, altering the aquatic and riparian habitat diversity and area significantly.

Image showing a beaver lodge in one of the recovery areas.



Beaver habitat may be created by a single dam only a few meters long, or a complex of dams and ponds covering extensive areas. The raised water table can create impoundments of lacustrine, bog, marsh, and forested wetland types. Beaver dams are usually .5-2 meters high. Sticks, mud, and rocks are materials used to construct dams and lodges. As an alternative to lodges, beavers construct dens by tunneling into stream banks. Beavers also construct/excavate canals. Canals are usually about 1 meter wide and can be hundreds of meters long. They provide access to forage with aquatic escape from predators, and are used to transport woody materials back to the pond. Canals are frequently dammed, creating locks or supplementary ponds. Winter food caches are provisioned by anchoring fresh cut woody materials to the pond bottom.

Stream Size and Gradient

Where stream size is not the limiting factor, low gradient reaches of a stream provide the most suitable beaver habitat. Beaver habitat suitability is dependent upon a sensitive relationship between stream size and gradient. Maximums for stream size and gradient are limited by dam resistance to washout (Allen 1983; Beier and Barrett 1987; McComb et al. 1990). Minimum stream size is limited by the ability to provide beavers escape from predators, transportation for woody materials, and winter cover for food caches and den

entrances. Within these limits, the greater the stream size the less the gradient must be (Beier and Barrett 1987).

Low gradient stream reaches are associated with broad valley forms and increased flood plain areas (Flint and Skinner 1974), which when flooded by dam construction, allow larger pond/riparian vegetation areas and the construction of canals (Gard 1942; Slough and Sadleir 1977).

Research conducted in the Blue Mountains of Eastern Oregon, indicate reaches of less than 7% gradient and stream cross-sectional areas 0.8-5.0 square meters (high-water depth and width) to be most suitable (McComb et al. 1990). The narrowly defined relationship between these two factors indicates the sensitivity of beaver habitat suitability to climatic variability (i.e., several years of drought), especially in arid climates primarily dependant upon winter precipitation for stream inputs, and characterized by high seasonal stream-flow instability. As a result, the upper and lower limits of beaver habitat within the stream system, may become intermittently abandoned and occupied in response to the effects of climatic variability on stream size and flow regimes (Ives 1942; Gard 1961; McComb et al. 1990). Beaver habitat suitability may be lowered by increased run-off and the exaggeration of seasonal stream flow fluctuations which can occur as the result of logging, road building, agricultural diversions, the influence of livestock, and the loss of upstream beaver habitat.

Stream Flow Stabilization

Beaver dams increase the capacity of surface and ground water storage. The effect is to slow and delay the release of water, resulting in the attenuation of stream flow rates during spring runoff and summer cloudburst freshets. This enhances stream flow rates during drought and dry summer months, and increases the availability of surface water to fisheries habitat and downstream agriculture. The influence of beavers on watersheds can mitigate the increased runoff and stream flow instability that results from livestock grazing, logging and road building. Increased stream flow stability reduces flooding and can transform an intermittent stream into a perennial one (Tappe 1942; Collier 1959; Wilen et al. 1975).

Nutrients and Sediment Trapping

"Dam-building changes the annual stream discharge regime, decreases current velocity, gives the channel gradient a stair-step profile, expands the area of flooded soils, and increases the retention of sediment and organic matter." (Naiman et al. 1988:754).

The ability of beaver ponds to trap sediments and organic material is substantial. The overall effect is to increase and stabilize the pool of biomass and nutrients within the watershed and improve ecosystem efficiency of the use and storage of organic inputs. The concentration of nutrients and the biochemical changes of water quality and quantity not only benefit the immediate beaver habitat, but also benefits the downstream ecosystem. (Naiman et al. 1986; Olson and Hubert 1994).

Small dams of 14 to 18 cubic meters of wood, are able to trap as much as 2000-6500 cubic meters of sediment. It was estimated if the sediment trapped by beaver dams of the Matamek River watershed (Quebec, Canada) were uniformly distributed throughout the stream system, the bottom of the entire stream would be covered with an additional 42cm of sediment (Naiman et al. 1986; Naiman et al. 1988). The concentration of sediments benefits fish spawning habitat by reducing the embedding of coarse gravels with fine sediments. Sediment trapping can mitigate the increased sediment loading caused by roads, logging, cattle, fire, and natural causes.

F, 5b

Effects on Stream Temperatures and Dissolved Oxygen

Observations of the effects of beaver activity in the Grande Ronde watershed stream rehabilitation project: *"Subinfiltration began immediately... Water from the creek began to filter underground through the dam and come out a short distance downstream...water leaving the meadow was 5 to 6 degrees(F) colder than the water entering ...temperatures in the restored reach were 8 to 10 degrees(F) colder and fluctuated less during the day than immediately upstream or downstream...".* (Hollenbach and Ory 1999)

Studies indicate that elevated stream temperatures and low levels of dissolved oxygen associated with beaver ponds, can be lethal to trout (Olson and Hubert 1994). Contrary to

this, a study in the coastal streams of Oregon found that cooler peak stream temperatures occurred in streams with beaver ponds, than those without (Leidholt-Bruner et al. 1992). Streams where temperatures tended to be lower as a result of beaver ponds, were in mountain watersheds of western states (Gard 1961).

"It is not surprising that studies from unlike areas often indicate grossly different conclusions." (Gard 1961:240).

Temp

Beaver ponds expose larger water surface areas to sunlight. Although increased solar exposure tends to drive up temperatures, stream temperatures will not necessarily escalate as a result. Other beaver habitat effects upon stream characteristics must be considered. Increased volume, flow rates, temperature stratification, flow characteristics through the pond, and thermal conductivity with ground water have a temperature stabilizing effect. During warm summer months, increased stream volume resulting from flow stabilization, increases the heat capacity of the stream, thus decreasing the effect solar exposure and ambient temperature will have upon stream temperature. The net effect of these factors can result in rapid lowering of stream temperatures (Hollenbach and Ory 1999).

While studies of beaver ponds in eastern and midwestern states found elevated water temperatures and dissolved oxygen reduced to levels lethal to trout (Olson and Hubert 1994; Gard 1961), dissolved oxygen levels at the outputs of beaver ponds in the mountain streams of western states were found to be nearly the same as that of their inputs and well within ranges safe to trout (Gard 1961; Leidholt-Bruner et al. 1992).

"The overall effect of the beaver pond is to add another dimension to the stream system and to increase stream habitat heterogeneity." (Bryant 1984:192).

During winter and spring runoff when stream temperatures may be near freezing, the spreading and slowing of water as it passes through beaver ponds accelerates the warming trend of stream temperature, and thereby increases food production and the growth of trout (Gard 1961; Olson and Hubert 1994).

Vegetation and Diet

"It is commonly stated that the beaver exhausts the aspen supply in the immediate vicinity of his pond and then migrates... [this] *leaves the general impression that the beaver mines out his environment... Actually, through the interaction of a number of biotic and geologic factors, he farms it."* (Ives 1942:197).

By the construction of dams beavers actively alter their environment in ways which increase the long term productivity of the riparian and aquatic vegetation they depend upon for forage. Beaver dams raise the ground water table, and increase the contact area and infiltration of surface water into adjacent soils, thus increasing the riparian area and its vegetative productivity. (Naiman et al. 1988; Lowry 1993). Canals and locks contribute to further increasing riparian area and shoreline complexity.

Most foraging by beavers occurs within 100 meters of the water. Their diet is comprised of a wide variety of herbaceous, woody, and aquatic plants. Herbaceous vegetation is the preferred food of beavers, however, in temperate climates availability is limited by short growing seasons, dry summer months which can desiccate plants, and winter snow cover. As a result, from fall through early spring, beaver diet becomes more dependant upon woody vegetation and aquatic plants. The leaves, twigs, and inner bark of woody vegetation is considered the most important food source to insure winter survival (Allen 1983).

Aspen, willow, cottonwood, and alder are the most common woody forage and dam building materials, however, preferred species vary in different geographic areas. Inundation caused by the raised water table of new (or expanding) beaver ponds, and beaver efficiency at tree falling, can have a dramatic effect on other tree species as well. One beaver can cut 200-300 trees per year (DeByle 1981). Although deciduous trees are preferred, beavers will fall conifers.

Where aspen occur along streams and waterways it is the first tree beaver select for food and dam building materials. Although aspen stands can be rapidly depleted by foraging and inundation, they often provide construction materials for new dams.

In some environments willows are the single most important tree species suppling the food requirements of beavers (Grasse and Putnam 1955; Neff 1957; Aleksiuk 1970). Willows are especially tolerant of repeated cutting and partial inundation (Scheffer 1941; Neff 1957). Beavers create an environment that favors the asexual reproduction of willows and cottonwoods. Grazing by domestic livestock in these areas can eliminate that reproduction, beaver food supply, and lead to the desertion and failure of dams with resultant erosion.

It is important to note that the beavers preference for herbaceous vegetation, relieves the browsing pressure from woody vegetation during its active growing season, late spring and summer. Beaver's tendency is to avoid eating young willow sprouts and to harvest more mature woody materials while they are dormant and the nutrients for regrowth are stored in the root system. Beaver's sharp, chisel like teeth cleanly cut woody stems, minimizing damage to the remaining plant. In contrast, domestic livestock impacts willow productivity during the active growing season. Browsing by sheep and cattle leaves stems shattered, susceptible to dehydration, and the invasion of disease (Kindschy 1985; Kindschy 1989; Harwood 1995).

Image of willow shoots showing cut stems and regrowth.

Willow cuttings are often left with some of the bark intact. As these materials are used for dam and lodge construction they tend to sprout in place and become a living part of the

structure. The beaver's planting and harvesting strategy, along with willow's vigorous regrowth response to beaver cutting, results in the expansion of willows (Harwood 1995).

If beaver foraging outpaces vegetation regeneration, they abandon the site and relocate. Although available forage and building material may be temporarily depleted, browsing stimulates new growth and shoot production, allowing rapid vegetation recovery and the possibility of reoccupation. The duration of occupancy of an individual site may be limited by the quantity and quality of the vegetation available. Where other marginally suitable habitat sites are nearby, alternating residence between 2 or more sites may provide the requisites to sustain a reproductive colony. The cyclic or intermittent occupation of marginally suitable sites can be important to maintaining beaver colonies in the tributary systems of a watershed where climate and topographical features limit the size and numbers of suitable sites.

Multi-Successional Pathways

"...we see a complex pattern that may involve the formation of emergent marshes, bogs and forested wetlands, which appear to persist in a somewhat stable condition for centuries." (Naiman et al. 1988:761).

The concept of *succession* is often defined as a successional sequence which leads to a relatively stable climax plant community (Cronquist 1971). The concept of *multi-successional pathways* (Naiman et al. 1988) is defined by a plant community and habitat type (seral stage), responding to environmental factors which cause succession back to a plant community/habitat type of a previous seral stage. A sedge meadow which follows the deterioration of an abandoned beaver pond, may become a bog/shrub or wetland forest environment, which in turn succeeds to a conifer forest, commonly considered a climax seral stage. At any seral stage, environmental events, such as fire, or if stream flows return to conditions more favorable to beaver occupation (i.e., in response to climatic variability), the plant community/habitat type may again become a wetland forest or beaver pond. The possible sequences of replacement of one plant community and habitat type with another are numerous (Cronquist 1971; Naiman et al. 1988).

Beaver population density and distribution in a stream system, depend on a dynamic equilibrium (Vannote et al. 1980) of many factors including disease, predation, and other factors which influence a stream system's biological community and physical structure. These factors create a "shifting mosaic" (Naiman et al. 1988) of habitat modification which both determines, and is influenced by dam site abandonment, emerging opportunities for colonization, or the reoccupation of former sites. Dam sites may be occupied cyclicly, intermittently, persist for centuries or be abandoned indefinitely.

A typical scenario following livestock presence and beaver absence is: destruction of the dam, dewatering of the pond, down-cutting of the stream channel, a rapid lowering of the water table and subsequent decline of the riparian vegetation. (Neff 1957; Parker et al. 1985; Harwood 1995).

"If the willows are destroyed, as they occasionally are by livestock, the beavers emigrate; if the beavers are trapped out, stream erosion proceeds to lower the water table and the willow die for lack of water." (Scheffer 1941:322).

"The difficulty in sorting out causes [of erosional down-cutting and degradation of streams] *is exacerbated in many places because the introduction of grazing tended to coincide with removal of beaver."* (Parker et al. 1985:37).

The reduced water velocity in beaver ponds increases the rate and area of sediment deposition. Accumulated sediments decrease the gradient and broaden the area of the floodplain, thereby increasing the floodplain's potential riparian vegetation resources. As a result, a stream system's carrying capacity for beaver population tends to increase with time. The scale of topographic alteration is easily underestimated. Over time periods spanning thousands of years (between the last ice and present day), the activities of beavers in mountain watersheds can perpetuate wetlands and create areas of low gradient terrain that are extensive on a regional scale. These topographic features of watersheds are often mistaken to be the results of glaciation or underlying geologic structure (Ives 1942). Low gradient meadows with a stair-step profile, and deep peat soils vertically honeycombed with woody debris, are a signature of previous beaver habitat that may persist for thousands of years (Ives 1942).

Fisheries

"The physical attributes of ponds appear to offer trout habitat superior to that in the streams except for the obvious deficiency of spawning gravels." (Gard 1961:225).

In the western United States salmonid/beaver habitat studies consistently relate greater salmonid productivity to streams with beaver habitat than those without. Although the invertebrate community of a beaver ponds tend to be comprised of the same species present in the remaining stream, the beaver pond produces a dramatic increase of invertebrate density, and a 2-5 times increase of invertebrate biomass. This provides an important food source for juvenile migratory fish and trout (Naiman et al. 1988). The average weight of fish residing in the beaver ponds may be as much as five times greater than those in the remaining stream (Neff 1957; Gard 1961). A few stretches of creek influenced by beaver activity can produce a large proportion of a river system's young fish (Johnson 1984).

"Key summer habitats for coho, age 0+ and age 1+ steelhead are beaver ponds, side channels, and pools respectively." (Everest et al. 1984:iv).

In headwater streams, the deep pools and greatly increased water volume of beaver ponds provide habitat important to fish survival during periods of low or intermittent stream flow (Gard 1961; Leidholt-Bruner et al. 1992). In climates where severe winter weather can freeze streams solid (i.e., high desert habitats) beaver ponds provide critical winter fish habitat with escape from ice (Olson and Hubert 1994).

Beaver ponds are particularly important to fish populations in watersheds that would otherwise be lacking pools formed by coarse woody debris (McComb et al. 1990). The tree cutting activities of beavers along streams, contribute to the availability of woody materials that form debris dams. Upwelling water tends to occur downstream of beaver dams and pools formed by woody debris. These areas of upwelling, in 2nd to 4th order streams, are the preferred spawning habitat of salmonid species (Baxter 2000). This influence on ground/surface water exchange, combined with sediment trapping, benefits fisheries by

improving the quality and quantity of spawning gravels, and by increasing habitat diversity (Naiman et al. 1986; Swanston 1994).

The existence of beaver ponds is sometimes perceived to be detrimental to salmonids because they occupy stream channel that may otherwise be riffles/spawning habitat (Marcus et al. 1990). The net effects of beaver habitat on salmonid reproduction is relative to a larger spatial scale than the effect of ponds displacing spawning gravels; and relative to a larger temporal scale than the potential detrimental effects caused by an event of dam failure/washout and the release of a fraction of the accumulated sediments.

"Many trout spawn in the short riffles between ponds...37 redds were observed between dams 1 and 13, a section of almost continuous beaver dams...It is not the number of eggs (within limits) that determines the number of adults resulting, but rather the survival rate of the eggs present." (Gard 1961:289).

Fish Passage Barriers

"*Grasse and Putnam, in their studies of beaver in Wyoming in 1955, photographed a [beaver] dam that was only 30 feet wide but was 18 feet high.*" (Rue 1964:589). This single dam impounded more than 10 million cubic feet of water (Grasse Putnam 1955).

Although the effects of beaver habitat are a part of the natural perturbation of stream systems in which native fishes have evolved, beaver dams are sometimes assumed to limit fish reproduction if/when they block fish passage. It is not always readily apparent how fish manage to negotiate dams. Often they can jump dams, bypass them through side channels, or pass through the interwoven sticks and mud. In a study of trout in Sagehen Creek (a small creek of the eastern slopes of the northern Sierra Nevada), brown, brook, and rainbow trout were marked and released to test their ability to cross a series of 14 beaver dams. With the exception of the lowermost dam, all dams were crossed in both directions during spring, summer and fall. The lower dam was crossed only in the downstream direction (Gard 1961).

In southeast Alaska, coho salmon densities were highest in streams with beaver ponds. Coho were able to jump dams as high as 2 meters and were found above all beaver dam complexes (Bryant 1984).

Where dams are barriers to fish movement, the question remains whether they limit the reproductive success of fish species; or does the existence of beaver habitat, by improving spawning/rearing habitat, increase the successful reproduction of adult fish (Gard 1961; Bryant 1984; Lowry 1993).

"a high percentage of steelhead redds were found just below beaver dams...Dam blockage was probably not a factor in redd location, since fish were observed above several dams in the area." (Lowry 1993:96).

History

Since the 1800's, streams in the western United States have been influenced by many forms of resource extraction that compound understanding beaver population distribution prior to trapping, and how the effects of human activities have limited the current distribution of beavers in watersheds. The effects of climatic variability on stream flow regimes, also alters beaver habitat suitability, and is a factor influencing current beaver distribution.

Systematic trapping of beaver began in North America in the 17th century. The Hudson's Bay Company and American brigades of trappers reached the upper Columbia River by 1826 (Johnson 1974). Trapping went unabated until about the turn of the century, 1900, when concern over low beaver populations resulted in moratoriums on beaver trapping in the United States and Canada. In most of North America beavers were completely extirpated. Regulated trapping resumed in the following decades (Scheffer 1941; Olson and Hubert 1994).

As an "agent of soil and water conservation" (Scheffer 1941) and to manage nuisance beaver, in 1920, the Biological Survey and the State of Washington Department of Game began a series of experiments involving the transplanting of beavers. In 1932, Oregon State

and federal agencies began a similar live trapping and relocation program. It was the perception of biologist at the time that beaver populations had rebounded, but had not successfully reoccupied their former range in the uplands of mountain watersheds. Some records of these projects and their results were found:

1) *Management Studies of Transplanted Beaver in the Pacific Northwest* (Scheffer 1941). Three-fourths of the released beavers disappeared from planting sites within a few days or weeks. This report lists the reasons for the low success rate of establishing colonies at release locations:
   a) Stream flow regimes unsuitable for beaver habitat.
   b) Unsuitable topography or excessive elevation (> 1800 meters in Oregon).
   c) Predation and poaching.
   d) Improper handling of beavers preliminary to planting.
   e) Insufficient or inappropriate browse and dam construction materials.
   f) Riparian vegetation impacted by livestock and elk.

   The conclusions were that successful transplanting of beavers is dependant upon careful site selection and the exclusion of livestock. The duration of established colonies varies from sites that beavers will exhaust the food supply within a few years and then emigrate, to sites that may be occupied indefinitely. Willow and beavers can exist in a virtual state of symbiosis, willow supplying the food, and beavers raising the water table to increase willow abundance (Scheffer 1941).
2) *Beaver Distribution and Planting Map, Okanogan Forest* (U.S.F.S. 1937). This map indicates the location of known suitable beaver habitat sites; the location of occupied sites; and the location, year and the number of beaver released in the Okanogan Forest.

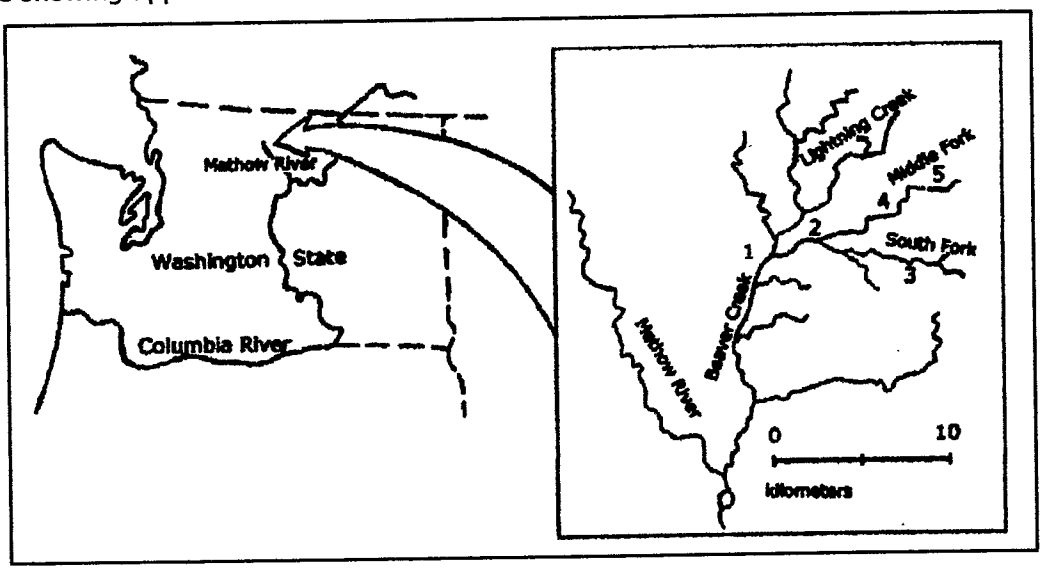
Methow Valley Study

Field Reconnaissance

To pursue understanding the current status of beaver in the sub-basin watersheds of the Methow Valley a limited field reconnaissance is of value. The proximity of Beaver Creek and the availability of the *Beaver Creek Stream Survey Report*, (Hamon 1993) and the *Beaver*

Distribution and Planting Map (U.S.F.S. 1937) qualify it as the most convenient (and aptly named) sub-basin to investigate with the limited resources available to this study. Beaver Creek is also of interest due to the U.S.F.S. beaver transplant and habitat rehabilitation project which began in 1990 on an abandoned beaver habitat site of the South Fork (South Fork Meadows).

Image showing approximate location of the reconnaissance site.



Beaver Creek

The Beaver Creek watershed is a sub-basin of the Methow River Watershed, a tributary of the upper Columbia River. Beaver Creek drains approximately 310 square kilometers in Okanogan County, Washington. Elevations range from 500 to 2245m. The climate is arid with most precipitation occurring in the winter as snow. Temperatures can vary from -33C to +41C.

From the confluence of Beaver Creek with the Methow River, to a point up stream approximately 13 kilometers, Beaver Creek is predominately low gradient, and broad valley form, typical of suitable beaver habitat. This part of Beaver Creek is privately owned and supports a valuable agricultural resource which is dependant upon stream diversion for

irrigation water. Agricultural demand for irrigation water exceeds available stream surface water supply during summer.

Upstream from the privately owned land, Beaver Creek enters D.N.R.(Wa. State) and U.S.F.S. land (Okanogan Forest) which is mountainous terrain characterized by a more steep gradient and narrower valley forms which offer fewer and more isolated suitable areas for beavers.

The 1993 stream report cites the presence of bulltrout, cutthroat, redband, coastal rainbow, and brooktrout. During summer 2000 a new culvert installation remedied a fish barrier at State Highway 153 (<1 kilometer from mouth of creek) and preceded the return of spawning steelhead (spring 2002 and 2003) to parts of lower Beaver Creek. Removal of the remaining fish barriers are in planning and construction. Extensive logging and high road density have impacted the watershed ecosystem to a great extent. A paucity of quality pool habitat and spawning gravels is cited by the *Stream Survey Report* as the limiting factors to the resident fish populations.

Field Reconnaissance (May-June, 2003), Notes, and Observations.

Site 1: Beaver Crk. Reach 1

This location is currently ponderosa forest and a state campground. The *Beaver Distribution and Planting Map* indicates this site is favorable for transplant and that no beaver were relocated here. Except for its low gradient and the presence of the stream, this site does not reflect that it was previously favorable beaver habitat.

Site 2 South Fork, Reach 3

The *Beaver Distribution and Planting Map* indicates beaver were occupying this site in 1937. The *Stream Survey Report* notes historic evidence of former beaver occupation and subsequent long term absence. Large aspen are present. Reach 3 is 1.4 kilometers long, has an average 7% gradient, with a steep narrow valley form. There is not an existing pond or meadow complex.

Site 3: South Fork, Reach 5 and the beaver rehabilitation project.

South Fork Meadows: The *Beaver Distribution and Planting Map* indicates that 5 beavers were planted in 1935. The *Beaver Creek Stream Report* records some of the recent history of this beaver pond/meadow complex and the U.S.F.S. beaver habitat rehabilitation project. In 1990 the site had been vacant of beaver since the early to mid 1980's. The stream channel of the South Fork was deeply incised in the flood plain and through breaches in the dam structures. The Stream Report describes the effects of cattle browsing, trampling of beaver dams and degradation of the stream banks occurring at the time of the survey.

In an attempt to raise the water table and restore the riparian vegetation willows were transplanted along the stream channel, and the construction of small check dams and livestock exclusion fencing was accomplished.

The total area of the existing dam/pond complex is approximately 20-30 acres. There is a series of old beaver dams, which are approximately 300 meters long and span the entire width of the flood plain. The presence of a >1 meter diameter spruce on top of one of these dams is evidence of the longevity of these structures. Three of these dams are well defined and each has one major breach, while others are more fragmented.

One beaver was released in 1995 but did not stay. In the spring of 2001 seven beavers were released. (J. Rohrer, U.S.F.S., pers. comm. 2003)

By the fall of 2001 beavers had constructed small dams at several places along the stream channel and within the breaches of the 2 uppermost dams, successfully raising the water table several feet in some areas. (personal observation). The shoot productivity and growth of willow and sedges across the floodplain was noticeably improved by the raised water table and has increased the availability of materials for consumption and dam building. The abundant new growth suggests that a dormant root structure was present.

In the spring 2003 it appeared that there was probably only one resident beaver (personal observation). Beaver activities had altered the pond/meadow complex to a large degree. The breaches and down-cut stream channels of the 2 uppermost dams were partially repaired with dams constructed of small willow sticks and mud excavated from the submerged stream channel. Willow abundance has increased dramatically and the old dam structures support vigorous willow and grasses. Many of the transplanted willows graphically illustrate repeated, seasonal beaver browsing and regrowth. In May, 2003 another beaver was released (J. Rorher, U.S.F.S., pers. comm. 2003).

Although the single pond above the uppermost of these old dams is approximately equal in elevation to the bottom of the old dam, the pond impounded runs along the base of the old dam for most of its length and is perhaps 1.5 meters deep in places.

The repair of the incised breach in the lower dam is approximately 2 meters high from the surface water below it, to the surface of the pond it impounds. Although this repair appears to present a barrier to fish passage, beaver slides and leaks in low spots of the old dam structures deliver water through the old dams and distribute it intermittently to different areas across the width of the floodplain as the water level is altered by the beaver's construction and repair activities. It is this rapidly changing control of water direction, by the activities of beavers, which account for fish passage routes which bypass the dam. Partially dammed side channels which lead from the ponds and return to the stream, combined with canals, slides, tunnels, and flood irrigated sedge/willow areas, offer a maze of possible fish routes.

Image of a narrow three-foot deep canal being filmed for workshops.

Reach five of the South Fork is recorded *(Stream Survey Report)* as 1.8 km in length, with an average 2% gradient, and a broad valley form. The existing fenced and currently occupied beaver habitat is a small portion of this stream reach. The remaining portions of this stream reach were previously extensive beaver habitat that has become dense conifer forest with few areas of willow/sedge meadow and open canopy. Remnant dams are common throughout the area. Spruce and fir trees up to .5 meters in diameter grow above, below, and on top of many of these dams. The few remaining, open sedge and willow areas are isolated from direct stream source water, by breaches in dams which spanned the flood plain and provided the lateral distribution of water delivered to these areas (below the dam). The relatively recent impact of livestock, upon willow and other deciduous woody plants is apparent and there is notable stream bank degradation associated with cattle.

The rehabilitation project demonstrates the value of livestock exclusion and the restoration of beaver occupancy. The existing open pond complex, inside the exclusion fencing, is a small part of the historical extent of beaver habitat in reach 5 of the South Fork.

Site 4: Middle Fork, reach 3

Although nine beaver were released at two sites in this reach in 1934, the size and dominance of spruce/fir/lodgepole pine among the remnant dam structures are evidence of the long term absence of a beaver colony. The remaining willows and woody shrubs have been heavily impacted by livestock grazing. The restoration of beaver to this site would mitigate the increased sediment loading and the degradation of downstream fish spawning habitat resulting from nearby upslope clear-cut logging and high road density.

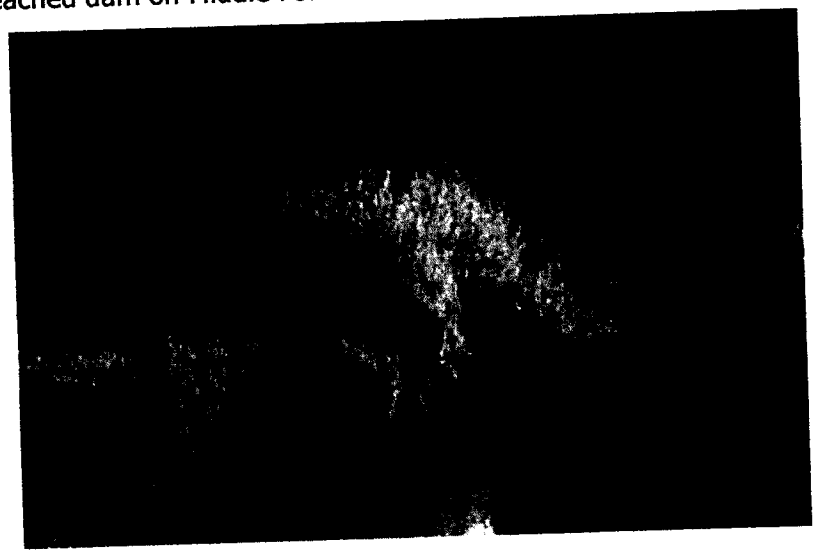
Image of an old, overgrown beaver dam.

Site 5: Middle Fork, reach 5

This reach was occupied in 1993 (Hamon 1993). The complex is estimated to be 30 acres. The most recent beaver cuttings suggest this site has been vacant of beavers for one year. The recent presence of cattle within the pond/meadow complex is apparent by the tracks,

droppings, and stream channel degradation. The upper and lower most dams are nearly intact but are deteriorating due to lack of maintenance by beavers and the impact of cattle. Remnants of numerous dams span the floodplain and have been breached. One of these has been incised to eight feet (from the top of the old dam, to the water surface in the breach) and exposes 2 meters of peat soil. Sandbars in this pond complex indicate the influent stream is heavily loaded with sand, largely derived from upslope clear-cut logging (Hamon 1993). This entrapment of sand in the pond complex precludes degradation of fish habitat immediately downstream. The Stream Report approximates the volume (surface water) of this complex to be 40% of the total surface water of the Middle Fork tributary, which is 11.2 kilometers in length.

Image of a breached dam on Middle Fork.



Undocumented sites

Personal communication with U.S.F.S. (J. Molesworth, U.S.F.S., pers. comm. 2003) indicates the existence of an unoccupied site with evidence of historical beaver occupation in a South fork tributary. This site is not shown on the *Beaver Distribution and Planting Map* and indicates incomplete knowledge or documentation of beaver habitat locations.

Implications and Summary

Previously, beaver habitat in the Beaver Creek watershed was more extensive than it is currently, and this may have been more apparent when the *Beaver Distribution and Planting Map* was made. Beaver habitat sites which were not successfully recolonized by the transplant program of the 1930's have converted to conifer forest. Beaver populations in the upland tributaries have not recovered from the trapping and near extermination of the 19th century.

The trampling of beaver dams by livestock initiates erosional processes that can down-cut and deeply entrench streams through longstanding dams that were well vegetated and otherwise erosion resistant. The influence of livestock transforms beaver habitat to a conifer dominate habitat type that is resistant to recolonization by beavers. This is an ongoing process that continues to suppress the distribution of beavers in low order tributaries of Beaver Creek. Although beavers will fall conifers, the lowered water table, conifer canopy shading, and livestock grazing, reduce the abundance and vigor of deciduous woody species necessary for dam/lodge repair and construction, and to provide food. Without sufficient resources to create aquatic habitat, ensure predator escape, and provide food cache reserves, winter survival is impaired and the presence of a resident colony is not possible.

The influence of beaver dispersion, that can occur if beaver populations are not suppressed, may return these areas of conifer forest to beaver habitat if livestock exclusion is implemented. The construction of check dams, planting willows, and transplanting beavers can expedite the restoration of beaver habitat.

Meadows which have recently (i.e., the last few decades) been beaver habitat and now have insufficient stream-flow (climatic variability/drought) to support wetlands, are common in the upper reaches of streams in the Okanogan National Forest. Livestock grazing of these areas reduces the probability of future recolonization by beaver, even if stream flow regimes return to more favorable conditions for beaver occupation.

The process of beaver habitat reduction observed in the Beaver Creek watershed is not unique. Similar processes have been documented in many watersheds of western North America. Trapping, poaching, and shooting of beavers is common in North America and contributes to the reduction of beaver habitat in stream systems (Tappe 1942; Collier 1959; Harwood 1995).

The historical model of pristine watershed ecology, prior to the trapping of the early 19th century, indicates concurrent abundant beaver and native fish populations (Johnson 1974; Lichatowich 1999). Beavers have been an integral component of maintaining watershed structure and ecological function since the end of the most recent glaciation. Almost two centuries of human activities have disrupted the interdependent relationship between beavers and watershed ecosystems. The potential for restoration of watershed ecosystems which produced native fisheries cannot be understood without consideration of wetland losses and fisheries habitat degradation which have occurred due to beaver absence/elimination.

The evidence is well documented that wetland areas are shrinking on a global scale (Noss et al. 1995). This is especially true in the western United States. Although the causes of wetland losses are numerous, the disruption and elimination of beavers is a factor. Beavers create and perpetuate wetlands.

The decline of threatened and endangered native fishes causes concern for the detrimental effects of reduced/interrupted in-stream flows resulting from agricultural stream diversions. Beaver habitat reduction exacerbates this conflict by decreasing stream flow stability, which negatively impacts the availability of water for agricultural use and the maintenance of stream flow/continuity during summer months.

Although beaver activities often conflict with human land use, the beneficial effects of beaver habitat have been undervalued. Insufficient effort to minimize human impact on beaver habitat has resulted in counter-productive effects to native fisheries and human land use purposes.

"In addition to their importance at the ecosystem level, these effects [of beavers] have a significant impact on the landscape and must be interpreted over broad spacial and temporal scales..." (Naiman et al. 1988:753).

"In practice... most modern conservation continues to focus on local habitats of individual species and not directly on communities, ecosystems, or landscapes." (Noss et al. 1986).

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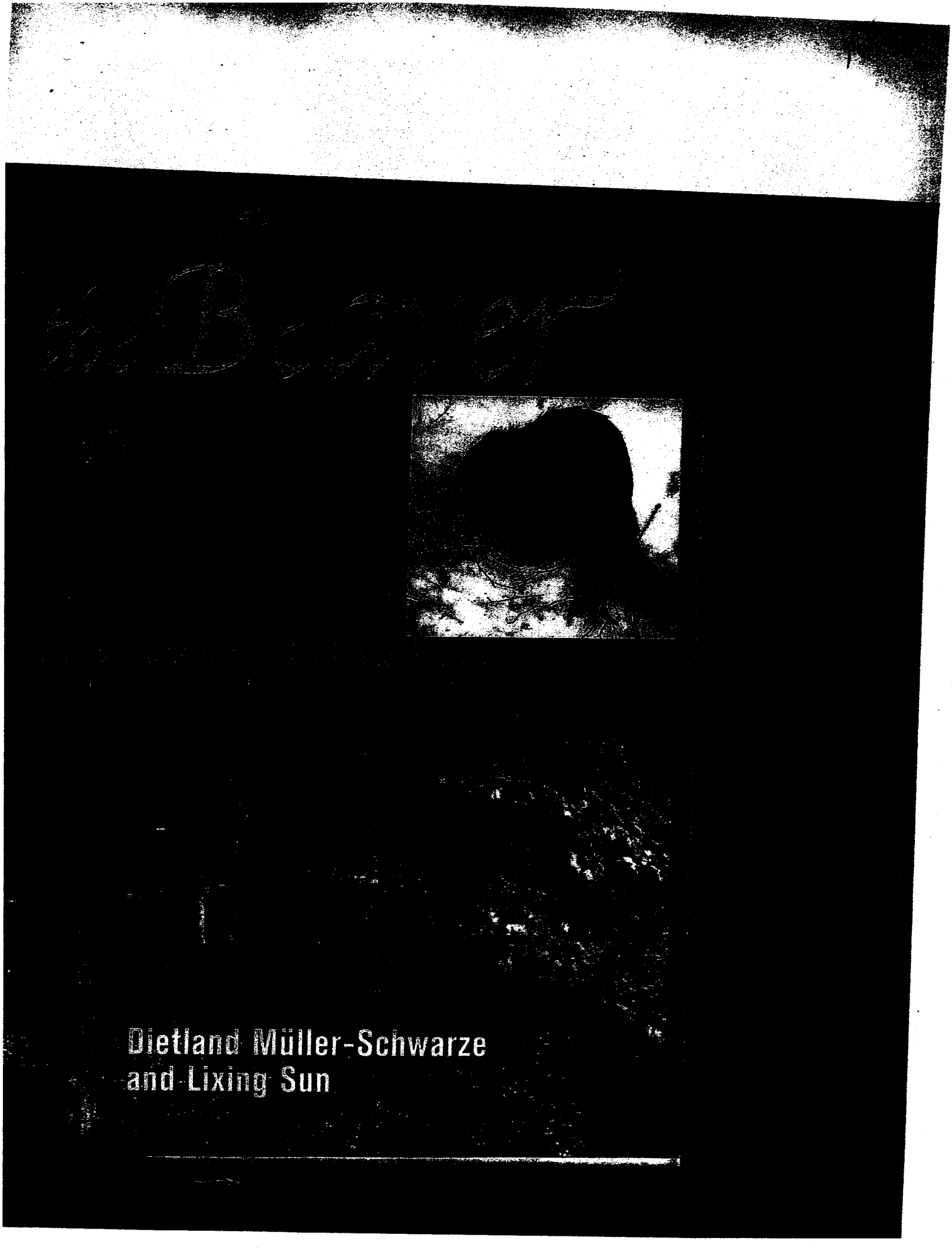

Dietland Müller-Schwarze
and Lixing Sun

chapter 11

Population Densities and Dynamics

Human exploitation of beavers decreases the survivorship of adults, but by freeing high quality colony sites, results in enhanced survivorship for dispersing pre-reproductives. Females breeding earlier in life in an exploited population attain smaller size at maturity and consequently suffer higher mortality than individuals breeding later at a larger body size. These trade-offs between fecundity, growth and survivorship are as predicted by recent theory on the evolution of life-histories.

M. S. Boyce, 1981

Population Densities

How many beavers can live in a given area? Because beavers hold territories that contain essential food and water resources, their population density in a given area is limited. Water is indispensable to beavers; therefore, the density of beavers is traditionally calculated as the number of colonies along a unit length of stream and the numbers of beavers in each colony. Suitable habitats can accommodate up to 1.2 colonies/km of stream (1.8/mile).[1–5] Nevertheless, others calculate the population density as number of colonies per area.

In Canada, beaver densities of untrapped populations in the western mixed forests of the national parks were 1.06 and 1.18 colonies/km.[2,7] By contrast, in New Brunswick trapped populations averaged only 0.33 colony/km², but untrapped ones 1.06 colonies. An unusually high density of 3.51 colonies/km² occurred in central Alberta, which resulted in problems caused by "nuisance beavers."[7] The maximum average density for Canada as a whole was estimated at 1.0–1.2 colonies/km².[7] Table 11.1 lists some beaver densities as colonies per mile and km stream in a number of North American States or Provinces.

Colony Size

The average number of beavers living in a colony ranges from 4 in western New York and Alaska[2] to over 8 in Massachusetts[8] and Nevada.[9] Colony sizes found in various studies are summarized by Müller-Schwarze and Schulte.[6] See also table 11.2.

| Beaver Densities (Number of Colonies per Unit Stream Length) in Various Areas

	No./mile	No./km
	0.64	0.40
inty, New York	0.87	0.54
tts	0.89	0.55
w York	0.93	0.58
uth Dakota	1.30	0.81
Reservation, Mass.	1.61	1.00
swick, N.J.	1.76	1.09

dified from reference 6.

2. | Numbers of Beavers per Family in Various Areas

	Average No. / Family
	4.1
	4.1
land	4.2
ks, N.Y.	4.3
Creek, Calif.	4.8
	5.1
State Park, N.Y.	5.4
	5.9
	6.3
le National Park, Mich.	6.4
usetts	8.1
	8.2

ference 6.

tion Composition

study in South Dakota, the age classes were represented as follows: There 5% kits, 22.6% yearlings, and 57.9% adults, defined as 2.5 years or older. age classes, males were slightly more numerous (male-female ratio: 00), but this difference was not statistically significant. Of the beavers aged rs and older, 66% were males, a significant sex difference.[10] Many possible for higher female mortality could be invoked. The age class composition ent studies proved remarkably similar (Fig. 11.1).

the other hand, kits and yearlings can constitute quite different propor- f the same population, depending on the phase of the population cycle. ample, at the Quabbin Reservation in Massachusetts, these age classes rep-

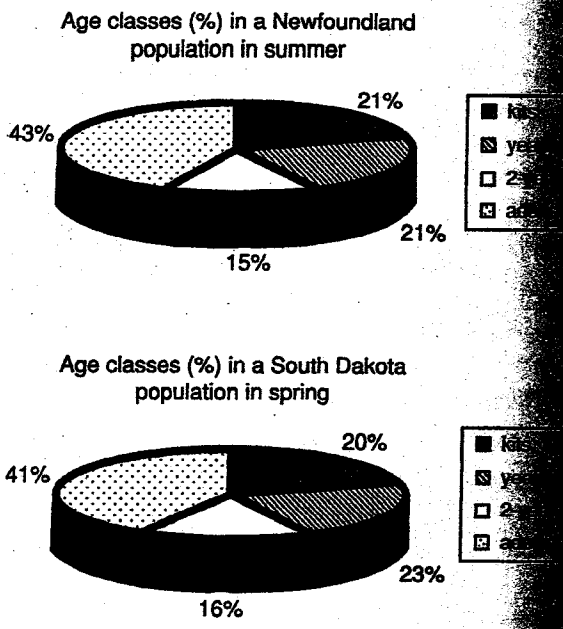

Figure 11.1 | Percentages of age classes in different populations can be very similar. (After data from references 3 and 10.)

resented a large and fairly constant percentage of all beavers during th phase, whereas they were less frequent when the population stabiliz steep decline[11] (Fig. 11.2).

Survivorship Curve

In populations where the exact age in years is known for a large num dividuals, a survivorship curve can be developed. As the beavers grow o survive. The first years of life see rapid attrition: yearlings represent a of the population, but 4-year-olds constitute less than 10%[12] (Fig. 11.3).

Population Dynamics

Population Growth

Beaver populations change slowly and lack the boom-and-bust p small rodents undergo. The size of an undisturbed population is regul by how much suitable habitat is available. Each family produces abou and contributes about two per year to the population. If three kits are die, and they start breeding within 3 years, the population would gr 10 years (Fig.11.4). But young beavers suffer high mortality due to sev lack of preferred food, and predation from carnivores. Wolves, coyo ines, bears, and even mink can depredate beavers, especially yearling

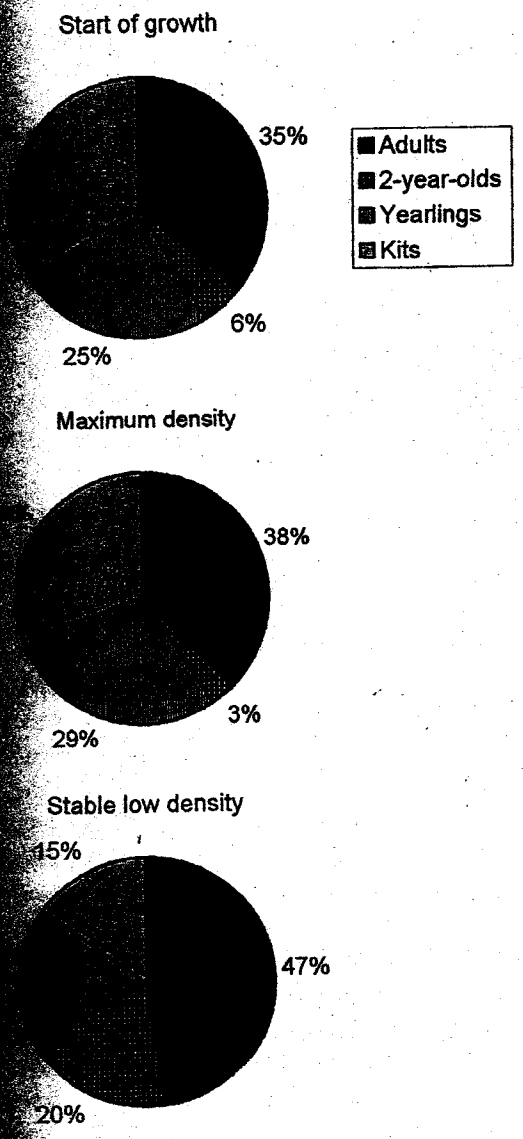

Figure 11.2 | Percentages of age classes during different phases of population cycle: growing population, maximum density, and stable low density after decline. Note the relative increase in adults and 2-year-olds and lower number of kits and yearlings in stable low density population. (After data from Busher and Lyons.[11])

stitute about one-third of a population. As many as 30% of the beavers classes can die in 1 year in Newfoundland.[3]

eaver population in Allegany State Park illustrates how it changes over ppers had eliminated all beavers around the start of the 20th century. In air of beavers from the Adirondacks was introduced, and 1 year later two were living in the park. Beavers occupied virtually the entire suitable

Educational Aspects

Julian Frazer

The beaver site benefits education as follows:

Education covers three major categories, General Public, visitors: The public benefits from observation as in going to a museum, interpretive center, or zoo or nature park. **The cost benefit of this is priceless, if a number has to be put on creating this it would in the hundred of thousands of dollars. We have this resource in place already for a fraction of that cost.**

Second is K-12 education: We have this resource in our city for use in add grades. Lesson plans can be created to benefit students in our schools and well as schools out of the area. **This outside nature classroom idea is outlined in our city's General Plan through the Alhambra Creek Enhancement Amendment.** The **cost benefit again is priceless** the number would be again in the hundred of thousands of dollars. **Again we have this in place for a fraction of the cost.** Curriculum can be made and even sold. The benefit to students in terms of social development and learning is also priceless and is stated in the following attachments.

Lastly is higher education research on wildlife and how it returns after habitat restoration. **We are at cutting edge of the movement of co-existing with wildlife in this unique setting**. The study areas are numerous, hydrology, wildlife management, social benefits, nature in cityscapes etc.. **Again the benefits are beyond the money already spent. And the frame work is in place just add research.**

See the following articles on benefits of environmental education programs:

"Nature-deficit disorder is not an official diagnosis but a way of viewing the problem, and describes the human costs of alienation from nature, among them: diminished use of the senses, attention difficulties, and higher rates of physical and emotional illnesses. The disorder can be detected in individuals, families, and communities."
— Richard Louv, Last Child in the Woods

Research and Studies

Volume One – February 2007

[+] view print version (PDF)
This C&NN resource includes an executive summary of each research report; full citation; and a PDF if available, or a link to each study in its entirety, or contact information if the study is not available online. Some are reports of individual studies in the form of original research; others are a synthesis of reports of various studies. While this is a listing of a sample of outstanding studies, the listing is not intended to be exhaustive. We welcome recommendations for additional research to include.

Annotated Bibliography by Cheryl Charles, Ph.D., President, Children & Nature Network

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Childhood Development

Direct Experience in Nature Is Critical and Diminishing

[+] view print version (PDF)

Nature is important to children's development in every major way—intellectually, emotionally, socially, spiritually, and physically. In his newest book, Building for Life: Designing and Understanding the Human-Nature Connection (Island Press, 2005), Dr. Stephen R. Kellert of Yale University devotes a chapter to the subject of "Nature and Childhood Development." Combining his original research with well-documented references to the research of others, this chapter is a powerful synthesis of what we know, and what we do not know, about the importance of nature to children's healthy development. Kellert states, "Play in nature, particularly during the critical period of middle childhood, appears to be an especially important time for developing the capacities for creativity, problem-solving, and emotional and intellectual development." He includes research to indicate optimal learning opportunities at age-appropriate times and differentiates between indirect, vicarious, and direct experiences with nature — with the latter less and less available to children. He urges designers, developers, educators, political leaders and citizens throughout society to make changes in our modern built environments to provide children with positive contact with nature—where children live, play, and learn. (Original Research and Synthesis)

Kellert, Stephen R. "Nature and Childhood Development." In Building for Life: Designing and Understanding the Human-Nature Connection. Washington, D.C.: Island Press, 2005.

Unstructured Free Play Brings Cognitive, Social and Health Benefits

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Unstructured free play in the out-of-doors brings a host of benefits to children—from being smarter to more cooperative to healthier overall. This well-documented article by two physicians builds a strong case for the importance of unstructured free play in the out-of-doors for all age groups, and especially young children. While concerned about the "obesity epidemic" in young children, the authors say that the health benefits from outdoor play are only one aspect of the overall benefits. They suggest that the concept of "play" is more compelling and inviting to most adult caregivers, parents and guardians than "exercise." The authors cite cognitive benefits from play in nature, including creativity, problem-solving, focus and self-discipline. Social benefits include cooperation, flexibility, and self-awareness. Emotional benefits include stress reduction, reduced aggression and increased happiness. Children will be smarter, better able to get along with others, healthier and happier when they have regular opportunities for free and unstructured play in the out-of-doors. (Synthesis)

Burdette, Hillary L., M.D., M.S.; and Robert C. Whitaker, M.D, M.P.H. "Resurrecting Free Play in Young Children: Looking Beyond Fitness and Fatness to Attention, Affiliation and Affect."

Direct Experience and Mentoring Are Key Elements

[+] view print version (PDF)

The focus of this recent research from Dr. Louise Chawla is on those factors that contribute to individuals choosing to take action to benefit the environment when they are adults. This is a reprise of earlier research by Dr. Chawla in the 1990s (Journal of Environmental Education, 1998, 1999). Positive, direct experience in the out-of-doors and being taken outdoors by someone close to the child—a parent, grand parent, or other trusted guardian—are the two most significant contributing factors. While lifelong activism is the primary focus of Dr. Chawla's inquiry, as reported in this article, her well-documented study includes citations and explanations of many additional benefits to children from early experiences in the out-of-doors. Creativity, physical competence, social skills, environmental knowledge, confidence, and problem-solving ability are among those benefits to children's development. Given the important role of adults in taking children into the out-of-doors, Dr. Chawla is specific about the attributes of the experiences those adult mentors provide. She states, the "adults gave attention to their surroundings in four ways—care for the land as a limited resource essential for family identity and well-being; a disapproval of destructive practices; simple pleasure at being out in nature; and a fascination with the details of other living things and elements of the earth and sky." Modeling those attributes while in the presence of the child does even more. As Dr. Chawla states, "The very fact that a parent or grandparent chose to take the child with them to a place where they themselves found fascination and pleasure, to share what engaged them there, suggests not only care for the natural world, but, equally, care for the child." (Original Research and Synthesis)

Chawla, Louise. "Learning to Love the Natural World Enough to Protect It," in Barn nr. 2 2006:57-58. © 2006 Norsk senter for barneforskning. Barn is a quarterly published by the Norwegian Centre for Child Research at the Norwegian University of Science and Technology, Trondheim, Norway. This article was written for a special issue in honor of the Norwegian child psychologist, Per Olav Tiller.

Contact with Nature Is Important for Children

Andrea Faber Taylor and Frances E. Kuo have contributed important research to the understanding of the impact of nature on people's lives, and specifically to the well-being of children. This particular article is a recent review of the literature and establishes what is known, and what is still missing, about the effects of contact with nature on children's lives. While the evidence is growing, this article is an important call to action for further research.

Taylor, Andrea Faber; and Frances E. Kuo. "Is Contact with Nature Important for Healthy Child Development? State of the Evidence." In Spencer, C. & Blades, M. (Eds.), Children and Their Environments: Learning, Using and Designing Spaces. Cambridge, UK: Cambridge University Press, 2006.

Outdoor Learning Enhances School Achievement, Self-Esteem and Self-Discipline

Nature-Smart Kids Get Higher Test Scores

[+] view print version (PDF)
The American Institutes for Research® conducted a study, submitted to the California Department of Education, of the impact of weeklong residential outdoor education programs. The focus was on at-risk youth, 56% of whom reported never having spent time in a natural setting. Comparing the impact on students who experienced the outdoor education program versus those in a control group who had not had the outdoor learning experience, results were statistically significant. Major findings were: 27% increase in measured mastery of science concepts; enhanced cooperation and conflict resolution skills; gains in self-esteem; gains in positive environmental behavior; and gains in problem-solving, motivation to learn, and classroom behavior.(Original research)

"Effects of Outdoor Education Programs for Children in California." American Institutes for Research: Palo Alto, CA: 2005. Available on the Sierra Club web site.

Environment-Based Learning Enhances School Achievement and Civic Responsibility

School Achievement Is Enhanced When Curricula Are Environment Based

Sponsored by many state departments of education, this 1998 study has an important place in documenting the enhanced school achievement of youth who experience school curricula in which the environment is the principal organizer. This study, completed in 1998, was followed by two related studies, conducted by the State Education and Environment Roundtable (SEER), both of which produced results consistent with this original study. (Original Research)

Lieberman, Gerald A.; and Linda L. Hoody. "Closing the Achievement Gap: Using the Environment as an Integrating Context for Learning." SEER: Poway, CA, 1998. "California Student Assessment Project." SEER: Poway, CA, 2000. Both of these studies are available at www.seer.org. The third and most recent of the SEER studies we are featuring is described below.

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More Evidence Corroborates Environment-Based School Achievement

This study provides further evidence to support the positive benefits on school achievement from environment-based study in schools. This 2005 study is consistent with the results of two precursor studies, cited above, "Closing the Achievement Gap" (1998) and the "California Student Assessment Project" (2000). Students in environment-based instructional programs score as well or better on standardized measures in four basic subject areas—reading, math, language and spelling. The environment-based programs also foster cooperative learning and civic responsibility, using the natural characteristics of the school grounds and local community as the foundational framework for the curricula. While the benefits are significant, this study also provides evidence for the challenges inherent in maintaining environment-based curricula in schools on a longitudinal basis, despite substantial evidence of benefits.(Original Research)

"California Student Assessment Project Phase Two: The Effects of Environment-Based Education on Student Achievement." SEER: Poway, CA, 2005. Available on the Web site of the State Education and Environment Roundtable (SEER) at www.seer.org.

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Outdoor Experience for Teens Has Self-Reported Life-Changing Results

[+] view print version (PDF)
A classic 1998 study by Dr. Stephen R. Kellert of Yale University, with assistance from Victoria Derr, remains the most comprehensive research to date to examine the effects on teenage youth of participation in outdoor education, specifically wilderness-based programs. Subjects were participants in programs offered through three old and well-respected organizations: the Student Conservation Association (SCA), the National Outdoor Leadership School (NOLS), and Outward Bound. The researchers used quantitative and qualitative research techniques, and parallel use of both retrospective and longitudinal study techniques. Results indicate that the majority of respondents found this outdoor experience to be "one of the best in their life." Participants report positive effects on their personal, intellectual, and, in some cases, spiritual development. Pronounced results were found in enhanced self-esteem, self-confidence, independence, autonomy and initiative. These impacts occurred among both the retrospective and longitudinal respondents in this study, which means, in part, that these results persisted through many years.

Kellert, Stephen R.; with the assistance of Victoria Derr. "A National Study of Outdoor Wilderness Experience." New Haven: Yale University, 1998. Available at the National Outdoor Leadership School web site.

There Are More Benefits from Naturalized Playgrounds and School Grounds

[+] view print version (PDF)
Randy White offers a variety of resources, articles, and recommendations for designing school grounds and playgrounds to optimize the benefits to children's development. One of his many excellent articles is "Young Children's Relationship with Nature: Its Importance to Children's Development & the Earth's Future." In addition to citing references and providing a succinct summary of the many benefits of informal and unstructured natural play environments for children, he distills the findings into a list of beneficial elements of naturalized play environments that any of us can use, from back yards to school grounds to neighborhood parks. Visit Randy White's Web site for additional resources and information at www.whitehutchinson.com. (Synthesis)

White, Randy. "Young Children's Relationship with Nature: Its Importance to Children's Development & the Earth's Future."

Schoolyard Habitat Projects Bring Natural Benefits to School and Students

This brief article by Mary Rivkin is an important reminder of the importance of bringing natural habitats to school grounds as places for natural learning. When the article was written in 1997, there was a burgeoning movement in the U.S. to have schoolyard habitat projects—places of natural and rich learning, integral to the curriculum, and a respite for teachers, students and the community overall. We've literally lost ground in this respect. The concept remains accessible, important, and healthy. This article is a short, succinct summary of the natural benefits afforded from schoolyard habitat projects.(Synthesis)

Rivkin, Mary. "The Schoolyard Habitat Movement: What It Is and Why Children Need It." Early Childhood Education Journal. Volume 25, No. 1, 1997. Available on the National Wildlife Federation web site (Synthesis)

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Natural Settings Provide Psychological Benefits

"Coping with ADD: The Surprising Connection to Green Play Settings," by Andrea Faber Taylor; Frances E. Kuo; and William C. Sullivan (2001) is one of the earliest studies to explore the potential for contact with nature to have a positive effect in reducing the impact of attention deficit disorder in children. The study was designed to test two hypotheses: 1) Attention deficit symptoms will be more manageable after activities in green settings than after activities in other settings; and 2) The greener a

Naturalized School Grounds Enhance Creativity, Self Discipline, Health and Academic Achievement

Green School Grounds Foster Achievement and Responsibility

[+] view print version (PDF)
There are numerous studies that document the benefits to students from school grounds that are ecologically diverse and include free-play areas, habitat for wildlife, walking trails, and gardens. One major study is "Grounds for Action: Promoting Physical Activity through School Ground Greening in Canada" by Anne C. Bell and Janet E. Dyment. While this study has roots in concern about obesity in children, it documents results and benefits beyond weight loss. Children who experience school grounds with diverse natural settings are more physically active, more aware of nutrition, more civil to one another, and more creative. One of the major benefits of green school grounds is increased involvement by adults and members of the nearby community, from helping with gardens to enriching the lifescape of the school grounds. Concerned about policy implications, this report offers specific recommendations for actions communities can take, from local neighborhoods to cities, states, and provinces. (Original Research)

Bell, Anne C.; and Janet E. Dyment. "Grounds for Action: Promoting Physical Activity through School Ground Greening in Canada." © 2006 Evergreen.

Naturalized School Grounds Benefit Children and Communities

[+] view print version (PDF)
A precursor to the study above, this report, "Nature Nurtures: Investigating the Potential of School Grounds," is an important compendium of documented benefits from "greening" school grounds. It includes citations of benefits to students, from improved academic performance to lower exposure to toxins; benefits to teachers, from increased enthusiasm for teaching to fewer classroom discipline problems; benefits to schools, from reduced absenteeism to fewer discipline problems; and benefits to communities, from better community health to "banked social capital." The report provides recommendations and tangible examples of ways to transform traditional school grounds into "green" school grounds for enriched learning and other benefits.(Synthesis)

"Nature Nurtures: Investigating the Potential of School Grounds." © 2000 Evergreen. Available online at www.evergreen.ca

child's everyday environment, the more manageable their attention deficit symptoms will be in general. The results were positive. (Original Research)

Taylor, Andrea Faber; Frances E. Kuo; and William C. Sullivan. In Environment and Behavior, Vol. 33, No. 1, January 2001. © 2001 Sage Publications, Inc. Available on the web site of the University of Illinois Urbana-Champaign, at www.lhhl.uiuc.edu

- [>] read online

Access to Nature Nurtures Self-Discipline

This study focuses on the positive benefits to inner city youth, particularly girls, from access to green spaces for play. Even a view of green settings enhances peace, self-control, and self-discipline. While the results are most notable for girls, the evidence is not limited to the positive impact on girls. (Original Research)

Taylor, Andrea Faber; Frances E. Kuo; and William C. Sullivan. "Views of Nature and Self-Discipline: Evidence from Inner City Children." In the Journal of Environmental Psychology, 21, 2001. © 2001 Academic Press. Available on the Web site of the University of Illinois Urbana-Champaign, at www.lhhl.uiuc.edu.

- [>] read online

Nearby Nature Reduces Stress in Children

This study, reported in 2003, by Cornell assistant professor Nancy Wells, focuses on rural children and finds that even a view of nature—green plants and vistas—helps reduce stress among highly stressed children. Further, the more plants, green views and access to natural play areas, the more positive the results. (Original Research)

Wells, N.M., and Evans, G.W. "Nearby Nature: A Buffer of Life Stress Among Rural Children." Environment and Behavior. Vol. 35:3, 311-330. This study is not available online without purchase; it can be obtained by contacting Sage Publications.

- [>] purchase this study

Nearby Nature Boosts Children's Cognitive Functioning

A precursor to Nancy Wells' study reported above, this research, reported in 2000, shows

that proximity to, views of, and daily exposure to natural settings increases children's ability to focus and therefore enhances cognitive abilities. (Original Research)

Wells, N.M. "At Home with Nature: Effects of 'Greenness' on Children's Cognitive Functioning." Environment and Behavior. Vol. 32, No. 6, 775-795. This study is not available online without purchase; it can be obtained by contacting Sage Publications.

- [>] purchase this study

Design Places for Learning and Living with Children in Mind

Design Cities Where Children Can Play and Learn Independently

City planners and city leaders need to create safe and accessible places for children to play. As more and more children live in urban settings, cities need to be redesigned with children in mind. This study offers explicit evidence for the importance of natural play areas in cities, and suggestions for actions to take to achieve this outcome. The study includes a summary of the characteristics of cities and neighborhoods that need to be considered in order to create safe places for children to play independently, with all of the associated and documented benefits that will result. (Original Research)

Churchman, Arza. "Is There a Place for Children in the City." In the Journal of Urban Design, Volume 8, No 2, 99-111, June 2003. Available on the Web site of the University of North Carolina, College of Design, Natural Learning Initiative.

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City Parks Bring Social, Community Health and Economic Benefits

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The Trust for Public Land (TPL) is a premier conservation organization, responsible for protection of special public lands throughout several generations. Today TPL is concerned not just about setting lands aside for future generations, but making sure that young people and families enjoy them today. TPL recognizes that to connect with nature is to appreciate nature, now and for the long term. This comprehensive report, "The Benefits of Parks: Why America Needs More City Parks and Open Space," offers a clear look at socioeconomic factors affecting the availability of parks, the history of city parks, and the hopes for a revival of commitment to city parks. The report outlines benefits in a number of areas: physical, including remedies for inactivity and obesity; economic, with increased property values; environmental, with pollution abatement; and social, from crime reduction to strengthening communities. Add this report to your collection of those

that serve to document how safe places for children to play contribute to everyone's health and well being. Available on the Trust for Public Land web site. (Synthesis)

The Trust for Public Land (TPL), "The Benefits of Parks: Why America Needs More City Parks and Open Space."

City Parks Offer a Sense of Place

This brief article draws on solid research, some of which is independently referenced elsewhere in this list. Among the points made are that city parks offer a sense of place, opportunity for daily experience with nature, experiences that enhance school achievement, and antidotes to alienation. This American Planning Association City Parks Forum Briefing Paper is largely inspired by the work of Robin Moore, noted and pioneering landscape designer with a commitment to creating learning landscapes that optimize children's learning. "Natural spaces and materials stimulate children's limitless imaginations and serve as the medium of inventiveness and creativity," says Moore. Readers will find tangible reasons for the benefits associated with using city parks as places for learning as well as community-based examples and resources. (Synthesis)

"How Cities Use Parks to . . . Help Children Learn," Chicago, IL: American Planning Association, 2003 is available on line at www.naturalearning.org and www.planning.org.

- [>] visit the Natural Learning web site
- [>] visit the American Planning Association web site

Texas Parks and Wildlife Department has provided funding to the Children & Nature Network (C&NN) in order to have C&NN "research and provide an executive summary of 20 premier research reports supporting the importance of connecting children and nature." The information is made available on the Children & Nature Web site, www.cnaturenet.org.

"Nature-deficit disorder is not an official diagnosis but a way of viewing the problem, and describes the human costs of alienation from nature, among them: diminished use of the senses, attention difficulties, and higher rates of physical and emotional illnesses. The disorder can be detected in individuals, families, and communities."

— Richard Louv, Last Child in the Woods

Health Promotion International, Vol. 18, No. 3, 173-175, September 2003

EDITORIAL

Health and nature—new challenges for health promotion

Lawrence St Leger, **Associate Editor**

The time is right for health promoters to take a close look at the evidence of the impacts nature has on the health of individuals and communities. Why? Because we may actually be able to achieve more appropriate and sustainable conditions that support health than if we only address interventions that focus on a particular health issue, e.g. poor diet, sedentary behaviour or drug misuse.

The environment (and nature) have always featured as key components in health promotion models and concepts. Lalonde (Lalonde, 1974), Hancock and Perkins (Perkins, 1985), Kickbusch (Kickbusch, 1989) and many others incorporated ecological perspectives into their constructs of health. These models have been used to inform the development of health promotion practices and have been largely influential in the shaping of the extensive theoretical designs and implementation strategies of the settings movement (e.g. healthy cities, health promoting schools, health promoting worksites, etc.).

Yet, even with these holistic frameworks and maps, much of the emphasis of health promotion efforts have been driven by health jurisdictions, who see health promotion as a way of addressing specific mortality and morbidity outcomes. This is not surprising and there has been a well documented history of how the health sector has embraced health promotion principles and strategies to make major inroads in many countries and regions into areas such as safety, heart disease and alcohol (IUHPE, 1999).

Environmental factors, such as well-lit and safe walking places, have made substantial contributions to reducing injury and facilitating physical activity. There is considerable data on how the physical environment is a major contributor to individual and community health (IUHPE, 1999).

But what about the evidence for the effects of nature on health? Wilson has put forward a very strong argument about the health benefits of nature over two decades (Wilson, 1984; Wilson, 2001). His 'biophilia hypothesis' i.e. 'the innately emotional affiliation of human beings to other living organisms' spawned research which suggested that our relationships with nature are a fundamental component of building and sustaining good health (Wilson, 1984; Heerwagen and Orians, 1993; Suzuki, 1997; Frumkin, 2001).

The evidence about the influence of nature on the health and well-being of individuals and groups has emerged from a number of traditional disciplines, e.g. psychology and biology, and recent fields of research such as recreation and leisure, and wilderness therapy.

The evidence tells us that the movement of humans from rural to urban environments across the globe within the last 200 years has facilitated their disengagement from the natural environment (Axelrod and Suedfeld, 1995+). We do not experience the range of natural environmental stimuli of our ancestors—a built environment of concrete, cars, noise, high-rise housing and pollution has replaced it. The protective factors of nature for health improvement and sustainability have been reduced by our diminishing regular contact with nature.

It doesn't require much effort to address this problem. A considerable body of research shows that viewing natural scenes has a positive health impact. For example, Ulrich (Ulrich, 1984+), in a landmark study, demonstrated that hospital patients who viewed natural scenes, e.g. trees and animals from their wards, recovered faster, spent less time in hospital, required fewer painkillers and had fewer post-operative complications than those patients whose ward views consisted of other buildings and which were devoid of any appearance of plants and animals. In prison, having a cell window with views of plants and animals, e.g. birds, lowered the number of sick calls of prisoners (Moore, 1981+). A number of studies have demonstrated that office workers experienced lower job stress, higher job satisfaction, and fewer illnesses if they had views of nature than if they did not (Kaplan and Kaplan, 1989+; Lewis, 1996+; Leather *et al.*, 1998+).

Placing trees next to freeways and roads, and having roads pass through and by green areas, reduces driver stress as measured by blood pressure, heart rate and sympathetic nervous system changes (Parsons *et al.*, 1998+). In addition to physical health improvements, there is considerable evidence to suggest that psychological health is enhanced when a person views flora and fauna. Rohde and Kendle (Rohde and Kendle, 1994+) conducted a comprehensive literature review into psychological reactions to nature. They concluded that viewing nature reduces anger and anxiety, sustains attention and interest, and enhances feelings of pleasure.

The above benefits occur by *viewing* nature. Being *in* nature also impacts upon health. Many studies have shown significant health gains for those in contact with nature. Some of these relate to assisting new immigrants to a country to cope with the transition of migration. Wong (Wong, 1997+) reported benefits such as increased empowerment, feelings of integration, and willingness to participate. Exposure to nature was shown to reduce mental fatigue, irritability and accidents, and improve problem solving ability and concentration in people from urban areas who are located in a natural environment for a few days (Herzog *et al.*, 1997+).

Gardening is an international activity. For many it is propagating and growing one's own food supply and/or providing food for others. Millions of people who live in urban environments cultivate gardens of varying sizes. In many cities community gardens exist.

Lewis (Lewis, 1996+) and Furnass (Furnass, 1996+) provide evidence to suggest that gardening reduces stress, encourages nurturing characteristics, builds social networks and enhances social capital. Even indoor plants have a positive effect. They have been shown to improve office air quality, increase productivity and facilitate relationships between workers (Randall *et al.*, 1992+; Larsen *et al.*, 1998+).

Animals have contributed to our health for thousands of years. In addition to providing a food source, they have been shown to contribute to lowering blood pressure, coping with stress and reducing minor health problems (Maller *et al.*, 2002+). Companion animals are now an important part of enhancing recovery after operations, particularly amongst elderly patients. A major study by Anderson *et al.* (Anderson *et al.*, 1992+) demonstrated that pet owners had significantly lower blood pressure, cholesterol and triglyceride levels than non-owners. We have a strong desire to engage with animals, as evidenced by the fact that more people visited zoos and aquariums in the USA and Canada than attended sporting events in the early 1990s (Wilson, 1993+). Some emerging research indicates that many people engage in feeding wildlife, e.g. birds, because they derive considerable personal satisfaction and comfort from the interaction (Howard and Jones, 2000+).

What does this considerable body of evidence mean for health promotion? On the one hand it has confirmed the work of the early creators of health promotion models and frameworks. However, more importantly, it now emphasizes that we need to be even more vigilant in ensuring interactions with nature are uppermost in our health promotion policy development and interventions. As groups of professionals, we may need to be more proactive in making sure abundant open areas, where citizens can easily experience contact with plants and animals, service the communities in which we live. These can range from small parks in inner city areas to green belts between suburbs. We also need to be more proactive as a professional group in interacting with those who are responsible for the forests, plains and urbanized areas of our country or region. It is important that the considerable health benefits of nature are made clear to governments, farmers, developers and the general community.

New fields of study are emerging which draw on the benefits of nature to enhance or restore health. Ecopsychology or nature-guided therapy, wilderness experiences, horticultural therapy and animal assisted therapy all have a growing body of research data which points to the many health benefits of engaging with nature (Maller *et al.*, 2002+). Some of these approaches appear to be just as effective in achieving health gains as traditional drug-oriented treatment regimens.

Sadly, most of this has been known for centuries. Our indigenous peoples and many ancient societies knew how closely humans were connected to and linked with nature. They also knew about the consequences of poor care and lack of respect for our natural environment and its animals and plants (Martin, 1996+; Burns, 1998+).

David Suzuki and David Attenborough are just two of the high profile international advocates who seek to promote respect of nature and all its components. In health promotion, we need to be more familiar with the evidence and, in many cases, more

proactive in making sure our natural environments are protected. The health benefits are considerable. Physical, mental and spiritual health are all enriched when we engage with nature. It is a challenge for us to make sure it happens.

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BEAVERS M5002

Director		
November	$ 1,544	
December	1,062	
January	3,382	
	5,988 *	OT hours 17
Deputy Director		
January - June 2007	600	
August	229	
September	382	
October	687	
November	916	
December	1,276	
January	821	
	4,911 *	OT hours 24
Superintendent		
October	236	
November	709	
December	709	
January	1,397	
	3,052 *	OT hours 24
Corpyard labor & equipment		
October	324	
December	1,607	
January	7,920	
	9,852	
City Engineer		
August	333	
September	1,334	
October	1,000	
November	1,500	
December	1,500	
January	515	
	6,184 *	OT hours 12
Total Staff time & equipment	29,986	
Materials	1,605	
Skip Lisle	12,990	
PWA - original study	8,110	Not pd
PWA - current study	12,375	not pd
Police Staff	1,890	from Town
City Attorney	4,150	
Total	**$ 71,107**	

2/20/08

* These figures do not include any OT hours worked by Management Staff.

R

Subj: **The Beavers & the Government**
Date: 11/3/2007 12:54:40 P.M. Pacific Daylight Time
From: nancyvpeacock@yahoo.com
To: nancyvpeacock@yahoo.com

THOUGHT THIS WAS TIMELY, CONSIDERING THE MARTINEZ BEAVERS...

OUR GOVERNMENT (your tax dollars) AT WORK

The below was confirmed by Snopes.com at the following URL.
http://www.snopes.com/humor/letters/dammed.asp

The Dam

This is an actual letter sent to a man named Ryan DeVries by the Pennsylvania Department of Environmental Quality, State of Pennsylvania This guy's response is hilarious, but read the State's letter before you get to the response letter.
SUBJECT: DEQ File No.97-59-0023; T11N; R10W, Sec. 20; Lycoming County

Dear Mr. DeVries:

It has come to the attention of the Department of Environmental Quality that there has been recent unauthorized activity on the above referenced parcel of property. You have been certified as the legal landowner and/or contractor who did the following unauthorized activity:

Construction and maintenance of two wood debris dams across the outlet stream of Spring Pond.

A permit must be issued prior to the start of this type of activity.

A review of the Department's files shows that no permits have been issued. Therefore, the

Department has determined that this activity is in violation of Part 301, Inland Lakes and Streams, of the Natural Resource and Environmental Protection Act, Act 451 of the Public Acts of 1994, being sections 324.30101 to 324.30113 of the Pennsylvania Compiled Laws, annotated.

The Department has been informed that one or both of the dams partially failed during a recent rain event, causing debris and flooding at downstream locations. We find that dams of this nature are inherently hazardous and cannot be permitted. The Department therefore orders you to cease and desist all activities at this location, and to restore the stream to a free-flow condition by removing all wood and brush forming the dams from the stream channel. All restoration work shall be completed no later than January 31, 2006 .

Please notify this office when the restoration has been completed so that a follow-up site inspection may be scheduled by our staff.
Failure to comply with this request or any further unauthorized activity on the site may result in this case being referred for elevated enforcement action.
We anticipate and would appreciate your full cooperation in this matter.
Please feel free to contact me at this office if you have any questions.

Sincerely,
David L. Price
District Representative and Water Management Division

Here is the actual response sent back by Mr. DeVries:

Re: DEQ File No. 97-59-0023; T11N; R10W, Sec. 20; Lycoming County

Dear Mr. Price,

Your certified letter dated 12/17/05 has been handed to me to respond to.
I am the legal landowner but not the Contractor at 2088 Dagget Lane , Trout Run, Pennsylvania A couple of beavers are in the (State unauthorized) process of constructing and maintaining two wood "debris" dams across the outlet stream of my Spring Pond. While I did not pay for, authorize, nor supervise their dam project, I think they would be highly offended that you call their skillful use of natures building materials "debris." I would like to challenge your department to attempt to emulate their dam project any time and/or any place you choose. I believe I can safely state there is no way you could ever match their dam skills, their dam resourcefulness, their dam ingenuity, their dam persistence, their dam determination and/or their dam work ethic

As to your request, I do not think the beavers are aware that they must first fill out a dam permit prior to the start of this type of dam activity.

My first dam question to you is:
(1) Are you trying to discriminate against my Spring Pond Beavers, or
(2) do you require all beavers throughout this State to conform to said dam request?

If you are not discriminating against these particular beavers, through the Freedom of Information Act, I request completed copies of all those other applicable beaver dam permits that have been issued. Perhaps we will see if there really is a dam violation of Part 301, Inland Lakes and Streams, of the Natural Resource and Environmental Protection Act, Act 451 of the Public Acts of 1994, being sections 324.30101 to

324.30113 of the Pennsylvania Compiled Laws, annotated.

I have several concerns. My first concern is, aren't the beavers entitled to legal representation? The Spring Pond Beavers are financially destitute and are unable to pay for said representation -- so the State will have to provide them with a dam lawyer. The Department's dam concern that either one or both of the dams failed during a recent rain event, causing flooding, is proof that this is a natural occurrence, which the department is required to protect. In other words, we should leave the Spring Pond Beavers alone rather than harassing them and calling their dam names.

If you want the stream "restored" to a dam free-flow condition please contact the beavers -- but if you are going to arrest them, they obviously did not pay any attention to your dam letter, they being unable to read English.

In my humble opinion, the Spring Pond Beavers have a right to build their unauthorized dams as long as the sky is blue, the grass is green and water flows downstream. They have more dam rights than I do to live and enjoy Spring Pond. If the Department of Natural Resources and Environmental Protection lives up to its name, it should protect the natural resources (Beavers) and the environment (Beavers' Dams).

So, as far as the beavers and I are concerned, this dam case can be referred for more elevated enforcement action right now. Why wait until 1/31/2006 ? The Spring Pond Beavers may be under the dam ice then, and there will be no way for you or your dam staff to contact/harass them then.

In conclusion, I would like to bring to your attention to a real environmental quality, health, problem in the area. It is the bears! Bears are actually defecating in our woods. I definitely believe you should be persecuting the defecating bears and leave the beavers alone.

If you are going to investigate the beaver dam, watch your step! The bears are not careful where they dump!

Being unable to comply with your dam request, and being unable to contact you on your dam answering machine, I am sending this response to your dam office.

RYAN DEVRIES & THE DAM BEAVERS

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SIERRA CLUB
FOUNDED 1892

San Francisco Bay Chapter
Serving the counties of Alameda, Contra Costa, Marin and San Francisco

February 18, 2008

Mayor Rob Schroder
525 Henrietta Street
Martinez CA 94553

Dear Mayor Schroder,

Re: Support of keeping resident beavers on Alhambra Creek in Martinez.

The Sierra Club strongly opposes any attempts to relocate or euthanize the beavers that have colonized the downtown area of Alhambra Creek, as well as any attempts to irreparably harm their lodge, dam, and surrounding habitat. The Sierra Club urges the City of Martinez to leave the beavers, lodge, and dam in place, employing innovative mechanisms that will allow the long-term co-existence of beavers and humans in this urban area. The Club's Wildlife Committee offers their assistance to the City and residents in problem solving if any problems arise. Assistance in continued restoration efforts may also be considered.

Sierra Club representatives visited the site, looked at all the potential problems, talked with residents and visitors, and gathered information from beaver experts and other stakeholders in the process. The conclusion from our research is that leaving the beavers where they are is the best solution for all.

Beavers are essential to a healthy freshwater ecosystem. They create habitat for many species including birds, mammals and several fish species. The presence of the beavers in downtown Martinez marks a successful creek restoration effort, followed by re-colonization by one of California's keystone species. Such successes should be celebrated and highlighted, not undermined.

The problem of flooding in Martinez is long-standing, resulting from development within the floodplain of the creek. The problem has been exacerbated by increased impervious surfaces and stormwater run-off from upstream development and the change in storm intensity most likely a result of global warming. Climate experts warn that communities must address the problem of rising water levels in a comprehensive and intelligent way. The flooding issue will need to be resolved soon (see recent S.F. Chronicle article on global warming and flooding in California). The presence of the beavers in this creek is not the cause of the flooding problem and removing them will not make the problem go away.

2530 San Pablo Ave., Suite I, Berkeley, CA 94702 Tel. (510) 848-0800 E-mail: *san-francisco-bay.chapter@sierraclub.org*

The general community supports leaving the beavers where they are. This beaver family has received media attention around the world. It has local, state, national and international support. Residents and groups that have formed to keep the beavers can assist in the restoration process, and problem solve when and if problems arise.

The entire beaver operation (dam, lodge and foraging area) is visible from the street and the bridge. It is wheelchair accessible, easy for all to access and a unique opportunity to see these normally secretive creatures in the wild. It is drawing many people to the City which is a benefit to local business.

Most importantly, the Martinez beaver family presents an excellent opportunity for education and increased awareness of natural ecosystems for anyone who visits the city to see the beavers or who reads about their daily activities. This creek and beaver family have provided a unique outdoor classroom for children (our future planners) to study the interaction of humans and nature and the fact that thoughtful planning can allow for safe and healthy coexistence. The knowledge that children, students, planners and the general public can attain from these wild creatures far outweighs any potential inconvenience they may present.

The colonization of Alhambra Creek by the beavers illustrates that with a little human ingenuity an area that was previously destroyed can be restored and maintained to support the wildlife that was there long before the City was established. Representatives of the Wildlife Committee of the Sierra Club are willing to assist in any way possible. Please feel free to contact them at the number listed below.

Sincerely,

Terry Preston

Terry Preston
Wildlife Ecologist
S.F. Bay Chapter, Sierra Club
510-582-4179
mtmpreston@comcast.net

cc:
Councilmembers
Mark Ross
Lara DeLaney
Janet Kennedy
Michael Menesini