SECTION 4

The Clean Water Act:
Implementation on the Gila Watershed

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THE FEDERAL CLEAN WATER ACT: NONPOINT SOURCE POLLUTION

The federal Clean Water Act (CWA) was originally adopted in 1948. In 1967, the New Mexico state legislature approved the state's Water Quality Act, creating a Water Quality Control Commission (WQCC) and establishing the authority to adopt water quality standards consistent with the CWA.

Major changes to the CWA in 1987 included a requirement that the states develop management programs to address nonpoint source water pollution. Nonpoint source pollution of surface waters occurs when rain or snowmelt moving over and through the ground carries natural and human-made pollutants into lakes, rivers, streams, wetlands, or groundwater. Atmospheric deposition and hydrologic modification are other sources of nonpoint pollution (NMED, 2006c). Nonpoint source pollution is the leading cause of water quality degradation in New Mexico. Efforts designed to reduce nonpoint source pollution under provisions of the CWA are known as Section (§) 319 programs; in New Mexico, NMED Surface Water Quality Bureau (SWQB) is responsible for administering §319 programs in coordination with US EPA Region 6.

The state's approach to water quality management has evolved partly as a consequence:

> New Mexico's approach to water quality planning and management has evolved substantially over the last three decades, largely in response to the changing federal and state statutory mandates. Although the State currently conducts water quality planning on a statewide level, these efforts are evolving toward more of a watershed level focus in the context of the statewide planning efforts... That is, planning and management are moving toward a holistic strategy to protect or attain the desired beneficial uses and levels of water quality within a watershed, including, where appropriate, protection of human health and aquatic ecosystems. A successful watershed protection approach must be founded on cooperative interaction between the federal, state, and local levels of government, and between the public and private sectors (WQCC, 2003).

The New Mexico WQCC defines the state's water quality goals in the *Surface Water Quality Standards* (WQS; 2005, 2006) by designating uses for waterbodies, setting criteria to protect those uses, and establishing provisions to preserve existing water quality ("antidegradation" standards). To support these tasks, NMED SWQB has established a network of water quality monitoring and sampling sites across the state (see Maps 4 through 6 for sites on the Gila watershed). Intensive water quality monitoring is conducted on a rotating schedule throughout the state.

Biannually, the state documents the health of its surface waters in a two-part report. Under §305(b) of the CWA, the state must report the results from all assessments of surface waters; §303 requires a list of all surface waters that fail to meet state water quality standards. Waters not meeting state water quality standards are designated as "water quality limited" or "impaired," and are also often referred to as "listed" stream segments. New Mexico documents both its complete list of assessed waters and the evaluations that resulted in water-quality impaired designations in its combined §305(b)/ §303(d) Report (NM WQCC, 2004). Table 5 summarizes the combined §305(b)/ §303(d) Report for the Gila watershed.

Table 5. Combined 2004–2006 303(d)/305(b) listing for Gila and San Francisco River watersheds in New Mexico (from NMED, 2004a). The 305(b) list includes an assessment of water quality for all identified stream segments. 303(d) units are water quality limited segments, each requiring identification of wasteload and load allocations and development of a total maximum daily load; in the table, 303(d) items are those for which a TMDL parameter is shown. See final page of table for definitions.

Assessment unit	Reach length (mi.)	AU dbase ID	8-digit HUC	De-list parameter	TMDL parameter	Date to EPA or TMDL scheduled	Impairment category	Non-supported uses
Black Canyon Cr. (EF Gila River to headwaters)	25.2	NM-2503_21	15040001		Temperature	Nov-01	4A	HiQ coldwater
Canyon Cr. (MF Gila River to headwaters)	14.2	NM-2503_43	15040001		Plant Nutrients	Dec-01	4A	HiQ coldwater
ditto					Turbidity	Dec-01		
Diamond Creek (EF Gila River to headwaters)	25.6	NM-2503_43	15040001		NA[2]		2	
Gila River (EF)	26.2	NM-2503_20	15040001		Al chronic	Nov-01	4A	HiQ coldwater
Gila River (MF)	36.6	NM-2503_40	15040001		NA[3]	2011	5/5A	HiQ coldwater
Gila River (Mogollon Cr. to Gila Hot Springs)	43.5	NM-2502.A_30	15040001	Turbidity		Dec-01	2	
Gila River (WF abv. Cliff Dwellings)	31.4	NM-2503_30	15040001				3	
Gila River (WF blw. Cliff Dwellings)	4.9	NM-2503_10	15040001		NA[3]	2011	5/5A	HiQ coldwater
Gilita Creek (MF Gila River to Willow Cr.)	6.3	NM-2503_45	15040001		NA[3]	2011	5/5A	HiQ coldwater
Gilita Creek (perennial reaches abv. Willow Cr.)	6.6	NM-2503_48	15040001				3	
Hoyt Creek (Wall Lake to headwaters)	20.0	NM-2503_26	15040001				3	
Iron Creek (MF Gila River to headwaters)	12.7	NM-2503_44	15040001				2	
Lake Roberts	68.4 ac[1]	NM-2504_20	15040001		NA[3]	2017	5/5A	Coldwater
Mogollon Cr. (Perennial reaches abv USGS gage)	12.6	NM-2503_02	15040001		Al chronic	Nov-01	4A	HiQ coldwater
ditto				Pb chronic		Nov-01		
ditto				SBD		Nov-01		
Sapillo Cr. (Gila River to Lake Roberts)	11.9	NM-2503_04	15040001		Turbidity	Dec-01	4A	HiQ coldwater
ditto				TOC		Dec-01		
ditto				Bio impair.		Dec-01		
Snow Canyon Cr. (Gilita Cr. to Snow Lake)	3.1	NM-2503_46	15040001	SBD		Dec-01	1	
Taylor Cr. (Beaver Cr. to Wall Lake)	2.6	NM-2503_23	15040001		Al chronic	Nov-01	5/5A	HiQ coldwater
ditto					Temperature	Nov-01		
ditto				Turbidity		2011		
Taylor Cr. (perennial reaches abv. Wall Lake)	19.8	NM-2503_24	15040001		NA[3]	2011	5/5A	HiQ coldwater
Turkey Cr. (Gila River to headwaters)	16.9	NM-2503_03	15040001		NA[3]	2011	5/5A	HiQ coldwater
Wall Lake	14.3 ac[1]	NM-2504_10	15040001		NA[3]	2017	5/5A	Coldwater
Willow Cr. (Gilita Cr. to headwaters)	7.7	NM-2503_47	15040001	Nutrients			2	

Table 5 (continued).

Assessment unit	Reach length (mi.)	AU dbase ID	8-digit HUC	De-list parameter	TMDL parameter	Date to EPA or TMDL scheduled	Impairment category	Non-supported uses
Bear Cr. (Gila River nr Cliff to headwaters)	31.7	NM-2503_01	15040002	Al acute	NA[2]	Dec-01	1	
ditto				Zn acute		Dec-01		
ditto				Cu acute		Dec-01		
Bill Evans Lake	1.5 ac[1]	NM-2502_B00	15040002				2	
Carlisle Cr. (Gila River to headwaters)	15.0	NM-2502.A_02	15040002	Al acute	NA[2]	Dec-01	1	
ditto				Cu acute		Dec-01		
ditto				Cd acute		Dec-01		
ditto				Zn acute		Dec-01		
Gila River (AZ border to Red Rock)	24.6	NM-2501_00	15040002	SBD		Dec-01	2	
ditto				Turbidity		Dec-01		
Gila River (Mangas Cr. to Mogollon Cr.)	14.0	NM-2502.A_10	15040002	SBD		Dec-01	2	
ditto				Turbidity		Dec-01		
Gila River (Red Rock to Mangas Cr.)	21.1	NM-2502.A_00	15040002	SBD		Dec-01	2	
ditto				Turbidity		Dec-01		
Mangas Cr. (Gila River to Mangas Springs)	6.2	NM-2502.A_21	15040002	SBD		Dec-01	4A	Marginal coldwater
ditto					Nutrients	Dec-01		
Mangas Cr. (Mangas Springs to headwaters)	17.8	NM-2502.A_22	15040002				2	
Apache Canyon (Tularosa R. to Hardcastle Cnyn.)	8.7	NM-2603.A_44	15040004	Conduct.	NA[2]	Dec-01	1	
Centerfire Cr. (San Fran. R. to headwaters)	16.1	NM-2603.A_50	15040004		Conduct.	Nov-01	5/5A	HiQ coldwater
ditto					Nutrients	Dec-01		
ditto					NA[3]	2009		
Mineral Cr. (San Fran. R. to headwaters)	19.6	NM-2603.A_20	15040004	Temperature	NA[2]	Dec-01	1	
Mule Cr. (San Fran. R. to Mule Springs)	10.5	NM-2601_01	15040004				2	
Negrito Cr. (South Fork)	14.5	NM-2603.A_43	15040004		Temperature	Nov-01	4A	HiQ coldwater
Negrito Cr. (Tularosa R. to NF/SF)	12.4	NM-2603.A_42	15040004		NA[3]	2009	5/5A	HiQ coldwater
San Fran. R. (AZ border to Dry Cr.)	15.7	NM-2601_00	15040004				2	
San Fran. R. (Centerfire Cr. to AZ border)	14.9	NM-2602_20	15040004		Nutrients	Nov-01	4A	Coldwater
ditto					Temperature	Nov-01		
ditto				Turbidity		Nov-01		
San Fran. R (Dry Cr. to Whitewater Cr.)	8.7	NM-2601_10	15040004				2	
San Fran. R (Largo Cnyn. to Centerfire Cr.)	19.8	NM-2602_10	15040004				2	
San Fran. R (Whitewater Cr. to Largo Cnyn.)	43.5	NM-2601_20	15040004	SBD		Nov-01	2	

Table 5 (continued).

Assessment unit	Reach length (mi.)	AU dbase ID	8-digit HUC	De-list parameter	TMDL parameter	Date to EPA or TMDL scheduled	Impairment category	Non-supported uses
Silver Cr. (Mineral Cr. to headwaters)	9.6	NM-2603.A_21	15040004	Conduct.	NA[2]	Dec-01	1	
ditto				Turbidity		Dec-01		
Trout Cr. (San Fran. R. to headwaters)	15.3	NM-2603.A_60	15040004		NA[2]		1	
Tularosa River (Apache Cr. to headwaters)	17.6	NM-2603.A_41	15040004				2	
Tularosa River (San Fran. R. to Apache Cr.)	22.0	NM-2603.A_40	15040004		Conduct.	Nov-01	4A	HiQ coldwater
Whitewater Cr. (San Fran. R. to Whitewater Campgrd)	6.9	NM-2603.A_10	15040004		Turbidity	Nov-01	4A	HiQ coldwater
ditto				Al chronic		Nov-01		
ditto				SBD		Nov-01		
Whitewater Cr. (Whitewater Campgrd to headwaters)	14.2	NM-2603.A_12	15040004		Al chronic	Nov-01	4A	HiQ coldwater

EF: East Fork; MF: Middle Fork; WF: West Fork; San Fran.: San Francisco; Nutrients: plant nutrients; SBD: streambed deposits; TOC: total organic carbon; Conduct.: conductivity. Chronic: at levels that create "a stimulus that lingers or continues for a relatively long period relative to the life span of an organism. Chronic effects include, but are not limited to, lethality, growth impairment, behavioral modifications, disease and reduced reproduction." Acute: at levels that create "a stimulus severe enough to induce a response in 96 hours of exposure or less" (both from State of New Mexico, 2002).
AU dbase ID: for identification purposes only. 8-digit HUC: Hydrologic Unit Code assigned by USGS. De-list parameter: Stream segment de-listed for this parameter since earlier TMDL was developed. TMDL parameter: exceeded pollutant value. Pb: lead; Al: aluminum; Zn: zinc; Cu: copper; Cd: cadmium.

Impairment categories: 1:Attaining the water quality standard for all existing and designated uses. 2: Attaining some of the designated or existing uses based on parameters that were tested, and no reliable monitored data are available to determine if remaining uses are attained or threatened, 3: No reliable monitored data to determine if any designated or existing use is attained. 4A: Impaired for one or more designated uses, but all necessary TMDLs have been developed that once implemented are expected to result in full attainment of the standard. 5/5A: Impaired for one or more designated uses and a TMDL is underway or scheduled.
All non-supported uses in the Gila watershed are for aquatic life. HiQ: High quality.

[1]Non-stream surface water body area shown in acres. [2] Not applicable: De-listed due to ephemeral or intermittent nature. [3] Not applicable, but one or more parameters now show non-support; scheduled for TMDL review at date shown.

Designated uses

Determinations of impairment by NMED are made in relation to the "designated uses" assigned to each stream segment. Designated uses are documented in the New Mexico WQCC *Standards for Interstate and Intrastate Surface Waters* (2005a, 2006d). The designation of use for each stream segment is important in setting water quality standards. If a designated use is inaccurate, water quality standards may be set unrealistically high or low. For example, temperature standards for warm-water fisheries are less stringent than those applied to coldwater fisheries. When more than one designated use applies to a stream reach, the more stringent criteria are used to determine impairment.

Other Provisions of Water Quality Standards

Triennial review. Water quality standards are reviewed every three years, in a process known as Triennial Review. New Mexico completed its last Triennial Review in July 2005 (NMED, 2006d). The review process allows the public an opportunity to participate in setting water quality standards. The WQCC publishes advance notice of hearings during which data and commentary are sought from interested members of the public, reviews public input during the following months, and then issues revisions to the WQS (WQCC, 2005).

Antidegradation. The state's Water Quality Management Plan also includes an "antidegradation" clause to protect existing water quality. Generally, the clause ensures that surface water quality will be maintained and protected where it exceeds standards, and that, at least for existing uses, will not be allowed further deterioration even where it does not meet an applicable criterion (WCQQ, 2003, p.19). Waters designated by the WQCC as "Outstanding National Resource Waters" are also protected from degradation; these are nominated for designation by WQCC and may include surface waters in national or state monuments, parks, wildlife refuges, or waters of "exceptional recreational or ecological significance" (see WQCC 2006b).

Clean Water Act terminology: a brief primer

- §319: Section of the Clean Water Act that targets nonpoint source pollution and provides support for improvement measures.
- Listed: Included on New Mexico's 303(d) list of surface water bodies that fail to support designated uses because of water quality impairments.
- Designated uses: Surface water bodies are used for specific purposes like fisheries, irrigation, domestic supply, or livestock watering. Specific standards for water quality apply to each designated use.
- NPS: Nonpoint source pollution; contaminants that enter surface waters from generalized sources rather than specific points, such as a pipe. NPS may include surface runoff of precipitation or inputs from stream bank erosion, for example.

Delisting. An impaired stream segment is removed from the 303(d) list ("de-listed") when sampling indicates its water quality, on average, is capable of supporting its designated uses, or when sampling becomes impossible due to lack of perennial flow. The rationale for water quality impairment designations and de-listings are documented for the historic record in the *Record of Decision* (NMED, 2004a). As shown in Table 5, a number of stream segments on the Gila watershed (e.g., Silver Creek)

have been delisted in recent years due to lack of perennial flow during the 2002 sampling visits. Some of these sites may have been historically ephemeral or intermittent; others may be reflecting only the current regional drought. In either case, re-classification as ephemeral or intermittent affects a stream's designated uses, and therefore the water quality standards applied to it, as described below.

"Ephemeral" waters flow only in direct response to precipitation or snowmelt in the immediate locality. Their streambeds are always above the water table of the adjacent region. Designated uses include livestock watering, wildlife habitat, limited aquatic life, and secondary contact. See WQS Section 20.6.4.97 for designated uses; Section 20.6.4.900 for water quality criteria.

"Intermittent" streams contain water only at certain times of the year, such as when flow enters them from springs, melting snow, or precipitation. Designated uses include livestock watering, wildlife habitat, aquatic life, and secondary contact. See WQS Section 20.6.4.98 for designated uses and Section 20.6.4.900 for water quality criteria.

"Unclassified" perennial surface waters are those not specifically identified in the WQS (for instance, some headwater reaches of San Francisco River tributaries downstream of Whitewater Creek may fall into this category) See WQS Section 20.6.4.99 and Section 20.6.4.900 for designated uses and water quality criteria, respectively.

The *WIPS:* §319(h) and then some

NMED's nonpoint source (NPS) program utilizes a voluntary approach to water quality improvement that focuses on watershed plan development and support for building watershed group formation and partnering efforts. Incentives for voluntary implementation of remediation efforts include technical support and competitive funding through §319(h) of the CWA for state and local agencies, nonprofit groups, and citizen watershed groups working to improve watershed health (NMED, 2006c). While §319(h) project funding in New Mexico is designed to target watershed improvement work for very specific surface waters—i.e., stream segments identified on the 303(d) list for water quality impairments—NMED's "ultimate goal is to manage a balanced program that both addresses existing impairments...*and prevents future impairments*" (NMED, 2006c; emphasis added).

The *WIPS* aims to support this goal by documenting as completely as possible both existing conditions and "the analyses, actions, participants, and resources related to development and implementation" (EPA, 2005) of improvement strategies not only on listed reaches, but watershed-wide. Specific reasons for this approach include:

- Identified water quality impairments often reflect generally poor watershed condition. Successful remediation strategies directed at reducing nonpoint source runoff will also tend to improve overall hydrologic condition.
- Some stream reaches, although themselves not technically "impaired," contribute pollutants to downstream listed reaches. Management practices designed to improve water quality on similar listed reaches are also applicable to these stream segments.

Go to Section 5 for information specific to §319 listed stream reaches, including:

- Detailed maps
- Links to TMDL documents
- Land management information
- Suggested management strategies
- Ongoing remediation planning and implementation
- Photos

- Because water quality standards pertaining to sporadic flow in intermittent stream channels are considerably less stringent than those for perennial waters, intermittent streams are less likely to be eligible for §319 funding. Nonetheless, watershed conditions that eventually contribute to water quality degradation in downstream perennial waters exist in areas where only intermittent flow now occurs—perhaps in part due to the deteriorated conditions themselves.

- In some areas, conditions may threaten existing water quality. The *WIPS* provides one means for those most familiar with these areas (landowners or management agency staff, for example) to locate the resources for developing preventative integrated remediation plans.

- Providing a watershed-wide information source can assist stakeholders interested in participating in the water quality triennial review process.

- Many identified impairments are exacerbated by reduced base (minimum) streamflow, because contaminant concentrations increase under these circumstances. Improvement strategies that work to sustain higher baseflow levels will have corollary water quality benefits.

- Supporting and documenting the results of remediation projects and strategies provides a science-based means of evaluating the most effective ways to enhance the ecological integrity that will ultimately produce the greatest benefits for water quality.

WIPS development and resources availability

A watershed plan like the *WIPS* is typically the creation of a group of individuals who agree to collaboratively identify shared goals and strategies for watershed improvement. Efforts over the course of more than a decade to create a watershed-wide group on the Gila watershed of New Mexico have repeatedly faltered. Discussions during the past year with stakeholder groups indicated no consensus on a current need for such a group, although this may change with time. The initial draft of this watershed planning document, published in October 2005, was developed from preliminary information gathered by the NMED SWQB and the watershed information coordinator. It was made available to all known watershed groups and agencies, and comments were requested for incorporation into this second edition.

Although no formal watershed-wide group accompanies the development of this WIPS, funding for its development also made available to stakeholders a variety of technical and data resources, proposal development assistance, and liaison capacity with agencies, funding sources, and other watershed groups (see Section 7, Resources). To describe the forum through which these resources are offered, we have continued to use the name adopted for the purposes of information dissemination and stakeholder engagement in the first draft of the planning document, the *Gila Watershed Partnership of New Mexico* (GWP). The name links New Mexico watershed improvement efforts to those of a

collaborative group in Arizona, the *Gila Watershed Partnership of Arizona*, which offered to share the name and logo for a potential New Mexico coalition of groups interested in watershed protection and improvement efforts that may transcend the state border.

A major GWP goal is maintaining the *WIPS* as a "living document" for stakeholder reference to information on water quality and other geographic-based data, financial and technical resources, or documented results from implemented management practices as a planning tool for future work and outreach. The comment sheet in Appendix A is included to allow interested readers to submit specific information for future editions of the *WIPS*. This information might include, but is not limited to, identification of subwatersheds of concern, suggested remediation practices, or descriptions of projects that were inadvertently excluded from this edition.

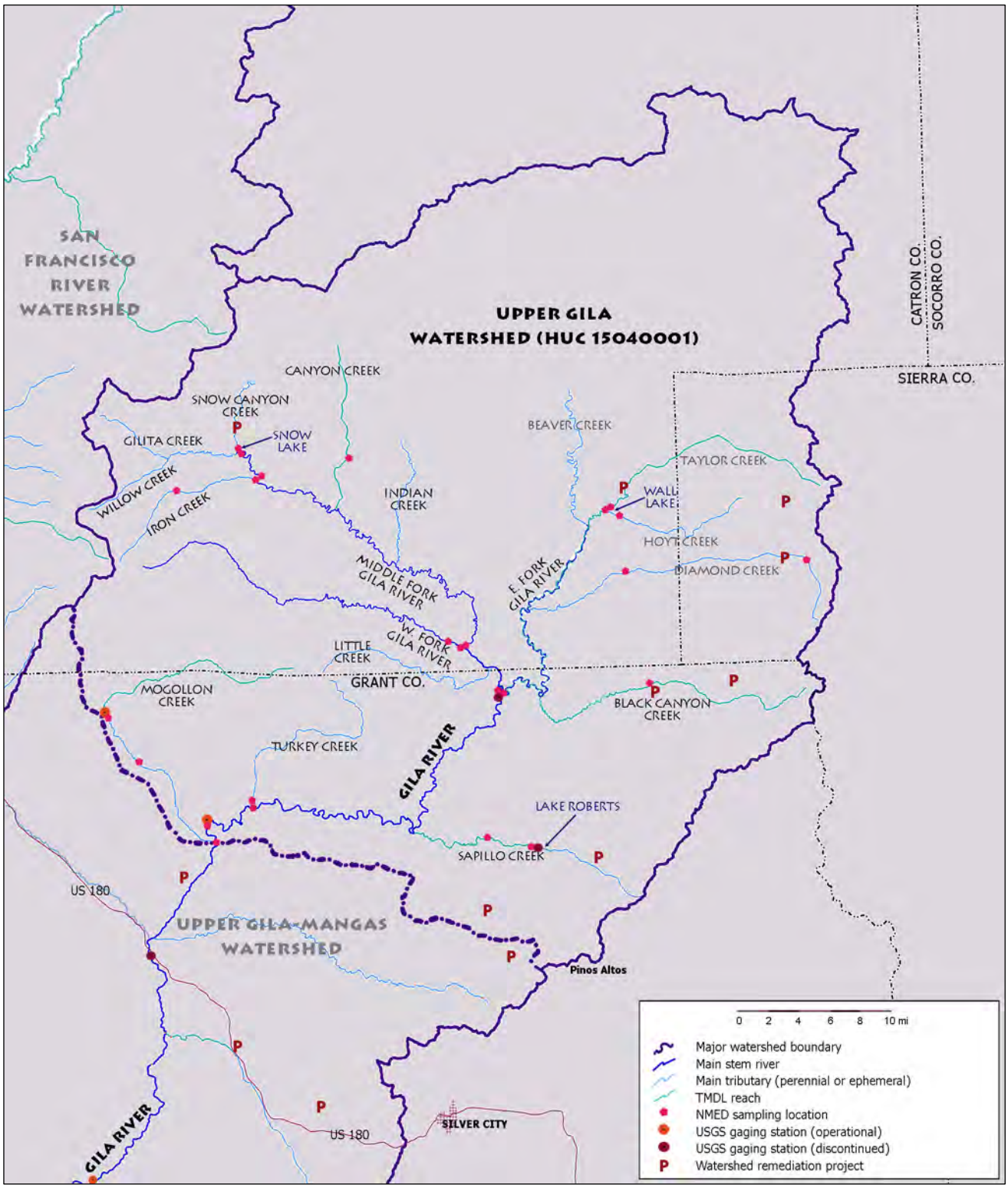
HUC maps and GIS data availability

The US Geological Survey (USGS) identifies watershed drainage areas, or "hydrologic units," by numeric codes, abbreviated as HUCs. Loosely stated, the number of digits within the code is inversely related to the size of the watershed delineated. For example, a 14-digit code might designate one small subwatershed, while an 8-digit code delineates the greater Upper Gila watershed. As shown in Table 5, the three mainstem river segments tributary to the Gila River at its confluence with the San Francisco include HUC 15040001 (Upper Gila); HUC 15040002 (Upper Gila-Mangas); and HUC 15040004 (San Francisco).

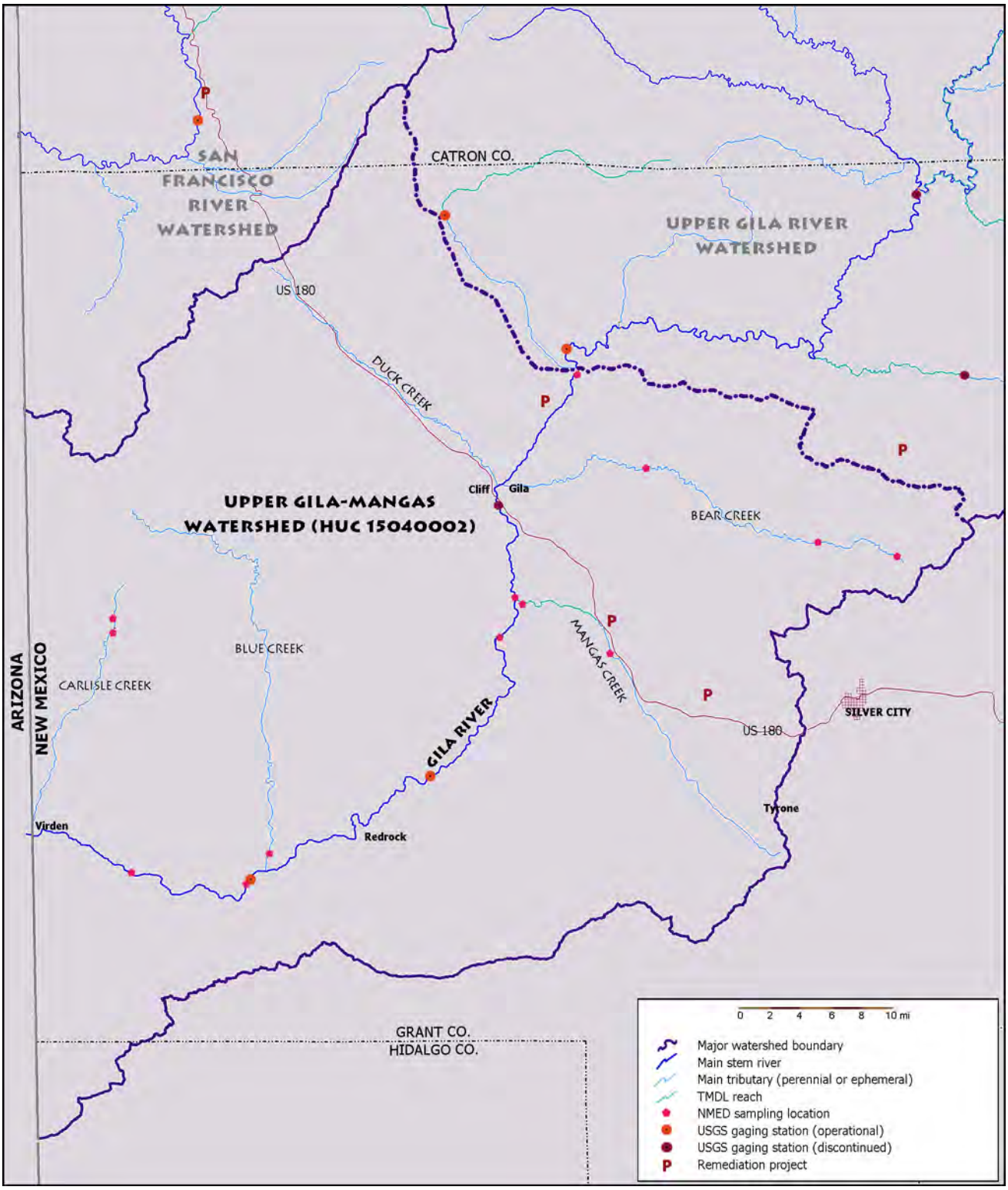
The maps on the following three pages delineate the major HUC boundaries within the New Mexico Gila watershed. For user reference, they include all sites at which water quality sampling is conducted or supervised by NMED (sampling or monitoring by volunteers at some sites occurs under *Quality Assurance Protection Plans* developed by NMED staff). Listed reaches are shown, as well as other major tributary channels, whether perennial or intermittent. The general locations of known remediation projects are also shown.

Additional details about all monitored stream reaches are contained in Appendix B of the *303(d)/305(b) Report* (WQCC, 2004), at: http://www.nmenv.state.nm.us/wqcc/303d-305b/2004/AppendixB/index.html

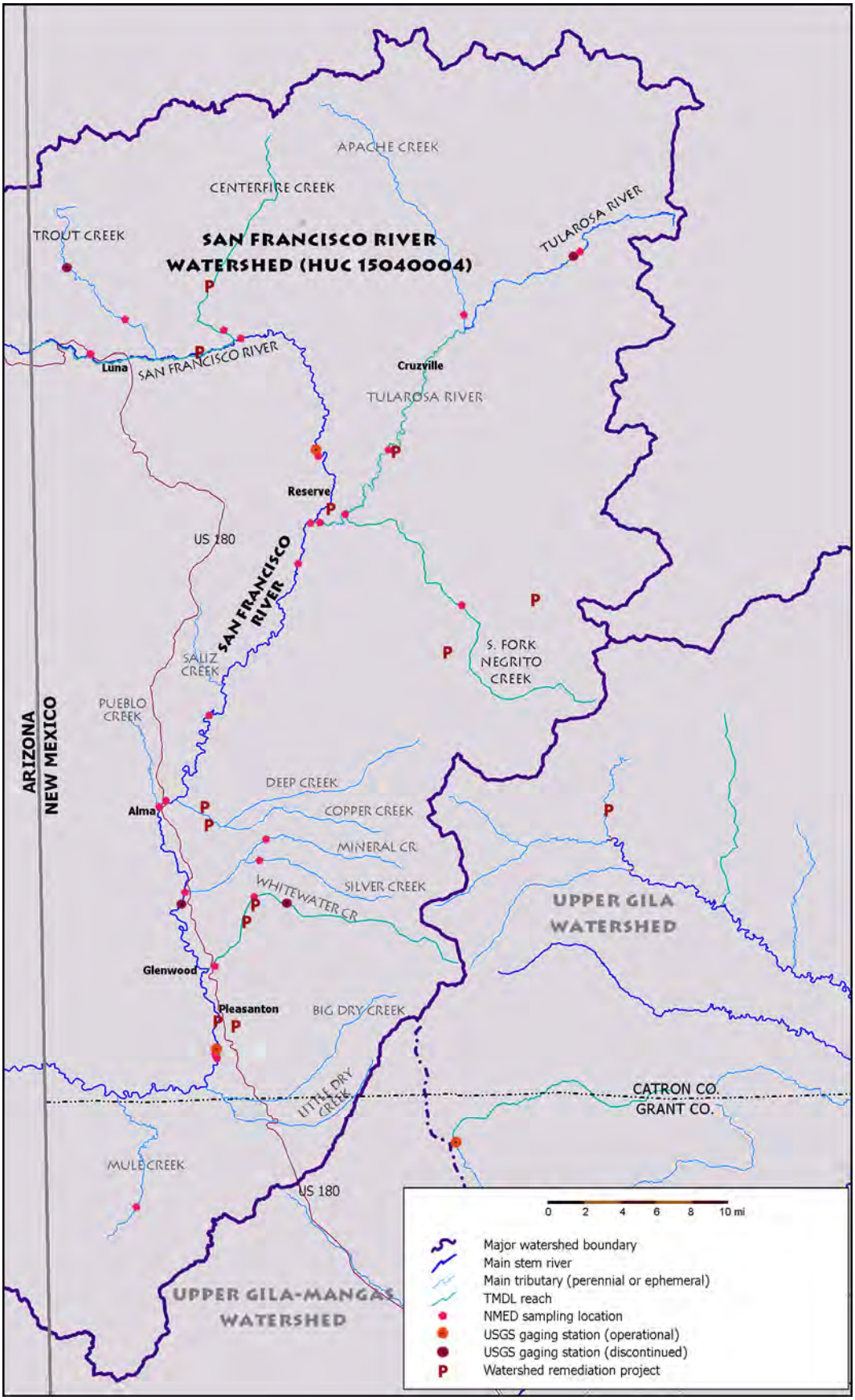
Like the other maps in the *WIPS*, these are intended to be viewable in paper format as well as digitally; they are therefore unable to depict in detail all of the data that are available through GWP to practitioners and managers. The Santa Fe office of NMED, however, is working to establish a GIS platform based on the mapped and other data, to be accessible to watershed stakeholders via Internet. The site is planned as an adjunct to the *WIPS* to provide straightforward data access for watershed-based planning and implementation efforts. During GIS project development, these data will be available through the watershed information coordinator at the contact information shown on the inside cover. See Section 6 for a listing of currently available data.



Map 4. Upper Gila watershed (HUC 15040001), including major tributary drainages, listed reaches, all NMED sampling sites, USGS streamflow gaging stations, and the general locations of known watershed improvement projects (excluding most GNF projects, too numerous to depict). See TMDL maps in Section 5 for more detail on listed reaches.



Map 5. Upper Gila-Mangas watershed (HUC 15040002), including major tributary drainages, listed reaches, all NMED sampling sites, USGS streamflow gaging stations, and the general locations of known watershed improvement projects (excluding most GNF projects, too numerous to depict). See TMDL maps in Section 5 for more detail on listed reaches.



Map 6. San Francisco watershed in New Mexico (HUC 15040004), including major tributary drainages, listed reaches, all NMED sampling sites, USGS streamflow gaging stations, and the general locations of known watershed improvement projects (excluding most GNF projects, too numerous to depict). See TMDL maps in Section 5 for more detail on listed reaches.

IDENTIFIED WATER QUALITY IMPAIRMENTS ON THE GILA WATERSHED

NMED SWQB's 2003 *Annual Report* identified eight principal causes of nonpoint source contamination of New Mexico surface waters: erosion from rangelands, agricultural activities, construction, silviculture, resource extraction, land disposal, unsurfaced roads, and recreation. They also noted the potential impacts of hydromodification works, including diversion of surface flow, channelization projects, and dredge-and-fill work (NMED, 2004b).

The New Mexico WQCC (2004) listed a number of possible factors of concern for water quality on the Gila basin, including historical degradation of the riparian community, habitat alteration, destabilization of streambanks, and forest management practices such as fire suppression. Other concerns included the presence of pathogens, sediment-laden runoff from forest roads, and recreational impacts caused by off road vehicles, camping and streamside trails, hydromodification, and silviculture projects. Levels of all contaminants identified on the Gila watershed may be elevated by localized NPS inputs, general watershed impacts, or some combination of the two. Whether of local or regional origin, most nonpoint source contamination in New Mexico waters tributary to the Gila River is derived from overland sediment runoff. Consequently, these water quality issues may apply to all surface waters on the Gila watershed, whether they are listed for impairments of designated use or not. Descriptions of identified contaminants and their potential implications follow.

Aluminum. The rock units of some parts of the Gila watershed are naturally abundant in aluminum. These include quaternary age basalt (16.8% Al_2O_3) and basaltic andesite (17% Al_2O_3). High aluminum concentrations in streams flowing through areas where the geologic composition includes aluminum can most likely be linked to naturally occurring sediment transport. However, many streams that exhibit exceedances of aluminum also show elevated turbidity levels, suggesting an increased rate of overland sediment delivery to the stream. Increased rates of sediment runoff often result from loss of native ground cover due to drought, intensive grazing, gullying, historic farming practices on floodplains, or encroachment of woody species, like pinyon-juniper, into former meadow areas. Ground disturbances due to mining activities also frequently result in increased aluminum concentrations where natural background sources exist. High chronic levels of dissolved aluminum are toxic to fish, benthic invertebrates, and some single-celled plants. The *Record of Decision* for the 2004–2006 §303(d)/§305(b) list notes that, on the Gila watershed, aluminum and other metals in surface waters are most often transported via suspended sediments. This mode of transport is less biologically damaging than the release of dissolved metals into surface waters, a less common occurrence typically linked to areas where mining wastes are high in sulfides. The common pH range in such situations is extremely low, from 2.0 to 5.0, with metal loading varying from small traces to extremely high values.

Conductivity. Conductivity is the ability of water to pass an electrical current. In surface water, conductivity is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions or sodium, magnesium, calcium, iron, and aluminum cations. The law of electroneutrality states that for a solution to be electrically neutral, the total charge on all positive ions (cations) must equal the total charge on all negative ions (anions). These ions move through a water column under the influence of an externally applied electric field (conductivity meter). The electric

current that flows through the water is proportional to the concentration of dissolved ions in the water – the more ions, the more conductive the water, resulting in a higher electrical current. Conductivity is affected by temperature; warmer water will measure relatively higher conductivity results. Conductivity is used as a measure of stream water quality as this measure tends to have a relatively constant range within a stream.

Plant Nutrients. Aquatic vegetation is normal in streams. However, an increase in plant nutrient levels—especially of nitrogen and phosphorous—creates excessive amounts of aquatic vegetation. Aquatic vegetation, chiefly algae and macrophytes, may increase dissolved oxygen above saturation during warm, sunny afternoons. These supersaturated levels can be harmful to fish in some instances, causing gas-bubble disease. Plants and algae also consume carbon dioxide, causing pH to rise. Nitrogen released during decomposition produces ammonia, and the amount of ammonia that is converted to the toxic un-ionized form is directly related to pH. Decomposition of aquatic vegetation reduces available dissolved oxygen, a potential limiting factor for other aquatic species. An increase in plant nutrients can come from a variety of point and non-point sources. Nutrients, primarily phosphorous and nitrogen fertilizers, are sometimes applied to the surface for vegetative growth. Soluble nutrients may reach surface or ground water through runoff, seepage, and percolation. Insoluble forms may be absorbed on soil particles and reach water by direct wash-off of debris and recently applied fertilizer. Other sources include animal waste, storm water runoff (carrying lawn fertilizer or pet waste), surface runoff transport of background nutrients bound to sediment, or septic tanks that are poorly installed or placed close to ground water. Concentrations of plant nutrients will also increase as stream base flow declines, one of the consequences of decreased floodplain and bank water storage. An excess of nutrients in stream waters causes eutrophication, or excessive aquatic plant growth. An excess of aquatic vegetation can affect water quality by depleting the stream of dissolved oxygen, reducing its capacity to support fish and other dependent species (US EPA, 1995).

Temperature. Thermograph measurements indicate above average temperatures for 4 out of 13 reaches for which TMDLs have been established on the watershed. Water temperature influences the metabolism, behavior, and mortality of fish and other aquatic organisms. Factors that impact water temperature are 1) hill slope and stream bank failure, which may increase the stream's width-to-depth ratio, causing more water surface to be exposed to solar radiation; 2) other changes in channel morphology, often the result of high-intensity flow events; 3) lack of riparian vegetation, resulting in reduced effective shade cover and thus increasing solar radiation; 4) decreased floodplain water storage, resulting in lower base flows; and 5) elevated sediment loads, which increase the amount of solar energy absorbed by the water. Temperature impairments may therefore be both an indicator and a result of deteriorated watershed and floodplain conditions.

Turbidity. Turbidity is a measurement of the reduction of the penetration of light through natural waters caused by the presence of suspended particles. Suspended solids include clay, silt, ash, plankton, and organic materials. Exceedances of suspended particles in the water can inhibit the normal growth, function, and reproduction of aquatic life. When these particles settle to the channel bottom, they may impact aquatic life forms. Increased turbidity may result from natural runoff after heavy rainfall. Anthropogenic factors that may increase turbidity levels include accelerated runoff from

exposed soil, improperly maintained or poorly designed roads, or activities that result in stream bank destabilization, removal of riparian vegetation, or inhibition of riparian regeneration. Road crossings, use of stream channels by motorized traffic, or poorly designed culverts may also increase the amounts of fine sediments in stream channels. Wetlands and beaver ponds tend to act as sediment traps, and the numbers of both on the Gila watershed have declined over the past 150 years.

Other contaminant sources:

Pesticides. Pesticides, if applied during vegetative management activities, may be soluble or insoluble. Pesticides in surface or ground water may result in toxicity problems, affecting water quality and food sources for aquatic life.

Debris. Silviculture or brush control practices can introduce elevated organic pollutant loads from tree limbs, tree tops, and other waste materials. They reach streams through direct pushing or felling into water drainages, and washout during storms. Decomposition of large volumes of organic material may place oxygen demands on surface waters, reducing available oxygen for aquatic life forms.

Milestone Measures

The concept of "milestones" is useful in watershed improvement planning. Milestones are used to define the control actions being implemented and their relative effectiveness. Interim milestones measure progress toward an ultimate goal; achieving an ultimate milestone is equivalent to reaching a desired condition established during watershed planning. For water-quality impaired stream reaches, attainment of TMDL standards is an ultimate milestone. The milestones listed here may be useful in watershed planning as a means of outlining management strategies and identifying the most effective ways to achieve them.

Quantifiable measures provide the most useful basis for evaluating progress toward achieving desired condition, and may help to reveal problems or conflicts among the strategies being implemented. (Protocols and references for monitoring techniques that can help managers obtain these measurements are in Sections 6 and 7.) Quantifiable, interim measures for overall water quality improvement can include:

- Percent restored riparian buffers: improved bank stability, filtration capacity, and shade cover
- Increase in length, density, and effectiveness of vegetative buffers between streams and agricultural activities or roads
- Decrease in sediment runoff from upland areas
- Decrease in volume of sediment inputs from ephemeral stream tributaries, including gullies
- Expansion of herbaceous cover (woody species thinning; improved grazing methods; wildlife management)
- Percentage of seasonal or permanent closures of poorly designed/unauthorized roads and stream crossings
- Historic wetland acreage rehabilitated

For specific water quality pollutants identified on the Gila watershed, target criteria may include:

Aluminum

- Measured increase in vegetated streambank length and vegetation density (filtration of metal-transporting sediments)
- Increase in wetland areas to filter and reduce metals concentrations found in streams
- Measured decrease of aluminum concentrations in water samples

Conductivity

- Measured increase in vegetated streambank length and vegetation density (vegetative uptake of ionic compounds)
- Measured reduction in total dissolved solids

Plant Nutrients

- Measured reductions in nitrogen and phosphorous contributions
- Measured reductions in aquatic plant production
- Moderation in diurnal fluctuations of dissolved oxygen and/or pH
- Measured increase in buffer zones between agricultural areas and stream banks

Temperature

- Measured reduction in total suspended solids and peak turbidity
- Reductions in temperature exceedances over the standard for designated use
- Percent increase in stream shade cover
- Measured change in channel dimensions (increased depth)

Turbidity

- Decrease in measured turbidity
- Decrease in excessive aquatic plant production
- Measured increase in vegetated streambank length, vegetation density, and extent of wetland areas (sediment filtration)

Implementation results, project completions, and improvements in water quality will be periodically documented in the *WIPS* as they become available, and targeted milestones may be adjusted as a consequence. NMED SWQB has established procedures for evaluating changes in water quality (Section 6); these will also be documented in updates to the *WIPS*.

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